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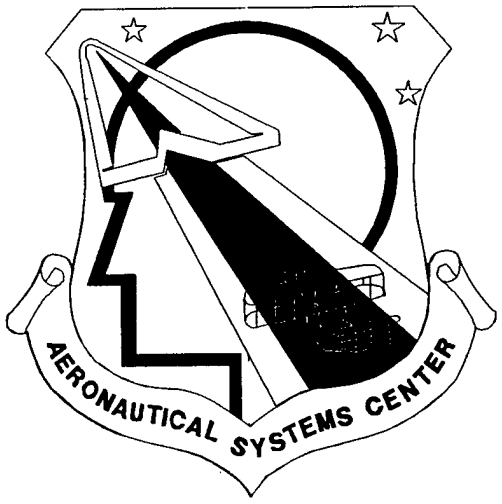

B-1B HUMAN FACTORS BASELINE STUDY REPORT

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NOVEMBER, 1999

FINAL REPORT FOR APRIL 1999 – OCTOBER 1999

ENGINEERING DIRECTORATE
AERONAUTICAL SYSTEM CENTER
AIR FORCE MATERIAL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-7101

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13. ABSTRACT *(Maximum 200 words)*
A Human Factors study was conducted on B-1B Blocks D, E, and F. The 1st study objective was to evaluate B-1B Blocks D, E, and F crew workload and situational awareness. The 2nd objective was to establish a measurable crew performance baseline for future B-1B Block upgrades. These objectives were studied in the B-1B Engineering Research Simulator (ERS) in a simulated full mission environment using eight B-1B crews. After training, the crews flew two missions. Workload and situational awareness were measured, a questionnaire was given, and all missions were video taped. Human Factors improvements were recommended.

14. SUBJECT TERMS
B-1B, LAUNCH ACCEPTABILITY REGION (LAR), JOINT DIRECT ATTACK MUNITIONS (JDAM), INTER-LEAVENED SEARCH AND TRACK (ILST) RADAR, SITUATIONAL AWARENESS, SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE

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EXECUTIVE SUMMARY

1. A Human Factors study was conducted on B-1B Blocks D, E, and F. The 1st study objective was to evaluate B-1B Blocks D, E, and F crew workload and situational awareness. The 2nd objective was to establish a measurable crew performance baseline for future B-1B Block upgrades.

2. These objectives were studied in the B-1B Engineering Research Simulator (ERS) in a simulated full mission environment using eight B-1B crews. After training, the crews flew two missions. Workload and situational awareness were measured, a questionnaire was given, and all missions were video taped.

3. The main findings of the study are that:

   a. Control and display improvements to the B-1B Block E Launch Acceptability Region (LAR) display (EB Page) are recommended to reduce the Offensive System Operator's (OSO) workload

   b. Improved targeting information is needed on the Target Summary display (E Page).

   c. Improved hung store training is needed for OSOs.

   d. A Digital Bull, Bra, and Compass Rose should be added as soon as possible to the DSO's Tactical Situation Display (TSD).

   e. Defensive System Operator (DSO) threat re-identification capability should be added.

   f. The Inter-Leavened Search and Track (ILST) radar mode is mechanized correctly and is useful.

   g. An ALR-56M radar warning receiver Repeater should be added to the front station.

   h. Weapon capability training for Joint Direct Attack Munitions (JDAMs) and Wind Corrected Munition Dispensers (WCMDs) is needed.

   i. A Data Link, Heads Up Display (HUD), and Color Heads Down Displays are the top three rated items that should be included in future Block Upgrades for the pilot and copilot.

   j. A Data Link, Color Heads Down Displays, and Moving Map are the top three rated items that should be included in future Block Upgrades for the Weapon System Operators (WSOs).

1.0 INTRODUCTION

The B-1B System Program Office Engineering Division (ASC/YDE) in conjunction with the Crew Station Evaluation Facility (CSEF) of the Engineering Directorate of Aeronautical Systems Center (ASC/ENFC) has conducted a series of applied research studies in human factors engineering and crew station design. They have used the B-1B ERS as a major tool in these endeavors. Some examples of past efforts include Defensive System Upgrade Program (DSUP) studies, Conventional Mission Upgrade Program (CMUP) studies, Block Upgrade studies, Crew Station Working Group (CSWG) support, and a Link 16 study. Government engineers have worked closely with the contractors, Boeing (B-1B) and Raytheon Training Inc. (CSEF), to support these human factors efforts. The products of these studies have been folded back into the B-1B system to make it a more useable and effective system.

1.1 STUDY OBJECTIVE

This is the first in a series of studies to look at the effects of B-1B Block upgrades on crew workload, situational awareness, and coordination. The objective of this study is to establish B-1B Baseline crew performance and workload measures and standards so that future B-1B Block Upgrades can be measured against an established, quantified baseline. Future studies will build upon this study's results to assess future Block Upgrade's impacts on crew performance and workload.

Broadly, the study looked at:

> The Block D improved Communication and Navigation Mission System (CNMS), including the Control Display Unit (CDU).
>
> The Block E unconstrained JDAM, WCMD, the associated LAR, and ILST.
>
> The Block F Integrated Defensive Electronic Countermeasures System (IDECM), the ALR-56M Radar Warning Receiver (including Audio), and the Fiber Optic Towed Decoy (FOTD).
>
> And, although not currently associated with any Block upgrade, the study also evaluated Digital Bull, Bra, and Compass Rose on the TSD, and an ALR-56M Repeater Scope on the top center of the Pilot and Copilot's glare shield.

2.0 METHOD

2.1 SUBJECTS

Eight B-1B crews participated in the study. A B-1B crew has a Pilot, Copilot, OSO, and DSO. The average pilot/copilot B-1B flight time was 1212.56 hours with a range of 150 to 2600 hours. The average number of B-1B flying hours for WSOs (i.e., either a OSO or DSO) was 966.38 hours with a range of 250 to 2250 hours. See Appendix 1 for the Bases the crews came from and their participation schedule. See Appendix 2, B-1B Baseline Study Questionnaire, Questions 1 through 8, for an in-depth look at the crew's experience profiles.

2.2 SIMULATION TEST BED

The CSEF's B-1B ERS was used to conduct the study. The CSEF's B-1B ERS contains the pilot, co-pilot, offensive and defensive stations. The system does not employ a motion base. For the Baseline Study, the pilot and copilot's stations were in the Block D configuration, the OSO's station was in the Block E, and DSO's station was in the Block F configuration.

2.3 SUBJECT TRAINING

Crews were given an orientation briefing covering the study's purpose, procedures, and schedule (see Appendix 3). Each crew was briefed on B-1B Blocks D, E, and F. Each crew was given B-1B ERS familiarization time as well as flying at least 2 practice missions. See Appendix 4 for the practice mission's details. See Appendix 5 for both the practice and the data collection mission's briefings.

The crews were taught the Subject Workload Assessment Technique (SWAT) and did the SWAT card sort in accordance with AAMRL-TR-89-023, Subjective Workload Assessment Technique (SWAT): A User's Guide.

Gary B. Reid - Armstrong Aerospace Medical Research Laboratory
Scott S. Potter and Jeine R. Bressler - Systems Research Laboratories, Inc.
July, 1989
Interim Report for Period June 1986-October 1988

2.4 MISSIONS

Two data collection missions were flown. See Appendix 6 for the data collection mission's details. The 1st data collection mission was a strike against three, static, pre-planned, "soft" and "hard" target arrays using JDAMs, both Mark 84s and BLU-109s. This 1st mission also had hung stores, a threat diversion, and a diversion to an alternative

landing field. The 1st data collection mission was called "UTTR". The 2nd data collection mission was a strike against three mobile target arrays using CBU-103 Combined Effects Munitions (CEMs) WCMDs. The 2nd data collection mission also had a tanker rendezvous and was called "Powder River".

Both data collection missions were in a high surface-to-air threat air environment (see Appendix 5, Slide 5) with the B-1B assumed to be a part of a larger (simulated) strike package. Both data collection missions were direct adaptations of missions regularly flown by B-1Bs at Ellsworth AFB. The data collection missions were flown in a counter-balanced order (see Appendix 1).

2.5 STATION/BLOCK EMPHASIS

a. Pilot/Copilot - Block D

   1) Communication/Navigation – CNMS CDU
   2) ARC-210

b. OSO - Block E - Conventional Mission Upgrade Program (CMUP)

   1) JDAM
   3) WCMD
   4) ILST

c. DSO - Block F - Defensive System Upgrade Program (DSUP)

   1) ASQ-184 - Radio Frequency Surveillance/Electronics Countermeasures (RFS/ECM) control panel, DSO Power Panel (PWR), Integrated Keyboard (IKB), 2 Electronic Display Units (EDUs), Multi-Function Display (MFD), Graphics Generator, DSO Track Handle, Audio Changes
   2) FOTD (ALR-50) CDU
   3) ALR-56M Radar Warning Receiver (RWR)
   4) Low Band On-Board Jammer

Some out-of-block features present in the B-1B ERS that were taught, simulated, and discussed were: ALR-56M Display Repeater on the top center of the pilot/copilot's glareshield and a DSO's TSD with a Digital Bulls Eye, Digital Bra, and a Compass Rose.

2.6 DATA COLLECTION

The following data was collected:

a. **Questionnaire** - A questionnaire was developed to obtain the crew's subjective ratings and comments on the test conditions. See Appendix 2.

b. **Workload** - SWAT. See Appendix 7. SWAT was used to assess mental workload by making relative comparisons of task conditions. SWAT is an accepted technique for determining if a task under one condition requires a greater mental workload than workload under another condition. SWAT was generally handled IAW "SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE (SWAT): A USERS GUIDE (U)" AAMRL-TR-89-023, Reid, Potter, & Bressler, July, 189. SWAT Version 3.1 was used to aid in the computer processing of the SWAT data. SWAT is broken down into 3 parts: Time Load, Mental Effort Load, and Psychological Stress Load. During training, crews accomplished the SWAT Card Sort. See also Appendix 3, Slides 6 – 12. SWAT Event Scores were collected at 4 pre-selected Mission "Freeze" points.

c. **Situational Awareness (SA)**. See Table 10. SA was generally handled IAW with "SITUATIONAL AWARENESS GLOBAL ASSESSMENT TECHNIQUE (SAGAT) AIR-TO-AIR TACTICAL VERSION, USER'S GUIDE" NOR DOC 89-58, Endsley, March 7, 1989, and "SITUATIONAL AWARENESS IN DYNAMIC HUMAN DECESION MAKING: THEORY AND MEASUREMENT", NOR DOC 90-49, Endsley, May, 1990. Situational Awareness questions were randomly selected from a list of 10 possibilities (see Appendix 3, Slides 16, 17, & 18) and were given at 4 pre-selected Mission "Freeze" points during a mission/mission segment to assess individual crew member's situational awareness. The possible questions were about either Own Ship SA or Environment SA in nature. For every crew, the same SA Questions were asked at the same freeze point. The crew SA responses were scored as either Pass or Fail, that is, the crewmember either had SA or didn't. Situational Awareness questions were asked just after the taking of SWAT ratings.

d. **Video Tape** - The crews were video taped during all data collection missions.

3.0 DATA ANLYSIS

3.1 SWAT DATA ANALYSIS

Statistical Package for the Social Sciences (SPSS), release 9.0 was used to analyze the SWAT data. The SWAT data was analyzed as 4 separate designs. The SWAT data was analyzed for the 1) crew, 2) pilots, 3) OSO, and 4) DSO. The dependent variable was SWAT, the independent variables were mission and freeze point. The crew's B-1B experience was treated as a between subjects variable. A Multivariate Analysis of Variance (MANOVA) was used for all 4 analyses. Each design looked at mission and freeze point. If the SPSS Multivariate criterion tests were significant at the alpha .05 level, more detailed analyses were done.

An anomaly of the SWAT program prevents entering data for more than 30 subjects. Since the subject pool exceeded 30, the data was divided into two groups: Pilots and WSOs. Rescaled SWAT values were obtained for the pilot and WSO pools. SWAT scores were used for the crew level (averaged crew SWAT scores), pilot level (averaged pilot and co-pilot scores), and for the WSOs. For the crew analysis, the pilot and WSO scales were averaged. For the other analyses, the pilot rescaled values were used for the pilot analyses, and the WSO rescaled values were used for the OSO and DSO analyses.

3.1.1 CREW ANALYSIS

For the crew analysis, each crew's SWAT scores were averaged together for an aggregated SWAT score at each freeze point for both missions. Figures 1 and 2 display the mean values for SWAT for mission, and mission and freeze point, respectively. Mission 1 has a greater average SWAT score than Mission 2 (23.97 vs. 19.03) and Mission 1, freeze point 4 has the greatest average SWAT score (31.03). Indices of central tendency and dispersion are shown in Appendix 8, Table 1 and correlation coefficients in Appendix 8, Table 5. There is a significant correlation between SWAT and crew, and SWAT and freeze point ($p < 0.01$).

There were no significant main effects for the general MANOVA. However, there was a significant interaction for mission and freeze point, ($p < 0.05$, Appendix 9, Table 1). Given the significant interaction, further analyses focused on the six simple main effects for mission and freeze point: four for mission comparing Mission 1 with Mission 2 for each level of freeze point, and two comparing freeze point under each level of mission. The simple main effects for freeze point for Missions 1 and 2 were not significant (Appendix 9, Tables 2-3). The simple main effects for mission were not significant for freeze points 1, 3, and 4; however, they were significant for freeze point 2 ($p < 0.05$, Table 1). Given significance, further analysis focused on the degree of association between the difference measure and the original SWAT scores (Eta Squared). Eta Squared is shown to be moderate and the difference in SWAT between Missions 1 and 2 is significant ($p<0.05$, Tables 1and 2 respectively).

Experience level, defined as B-1B experience hours, was analyzed as a between subjects variable for the crew MANOVA but was shown to be not significant ($p>0.05$). Therefore, it was no longer considered in subsequent analyses.

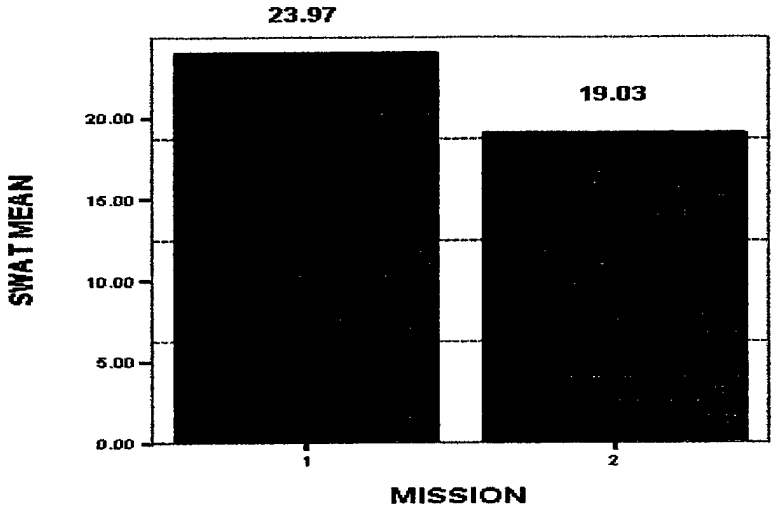

Figure 1. SWAT MEAM – CREW

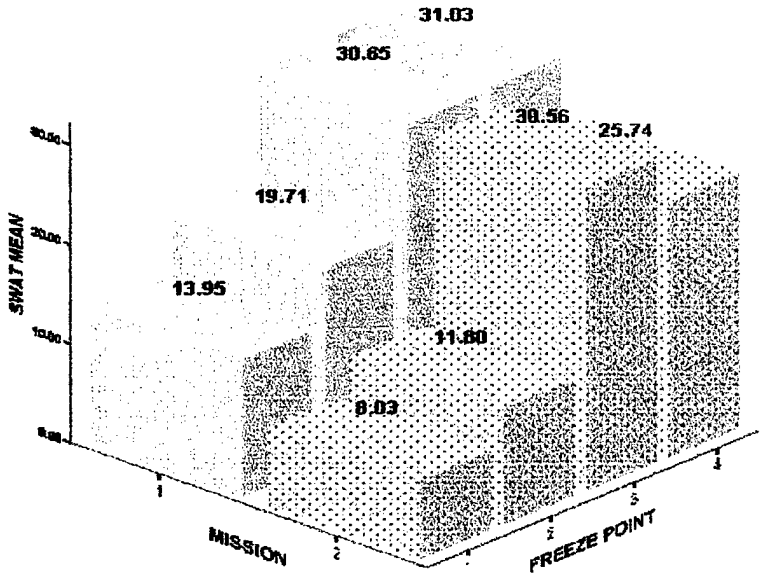

Figure 2. SWAT MEAN BY MISSION AND FREEZE POINT - CREW

TABLE 1. SIMPLE MAIN EFFECT – MISSION: TEST OF WITHIN SUBJECTS CONTRASTS FREEZE POINT 2 CREW

SWAT Source	MSN	Type IV Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Estimated Population Eta Squared+
MSN	Level 2 vs. Level 1	271.566	1	271.566	9.544	.021	.614	.555
Error(MSN)	Level 2 vs. Level 1	170.731	6	28.455				

+ Adjustment formula provided is from Bray, J.H. and Maxwell, S. (1990, p. 37) Multivariate Analysis of Variance. Sage Publications, Newbury Park.

TABLE 2. SIMPLE MAIN EFFECT –MISSION: PAIRWISE COMPARISION FREEZE POINT 2 CREW

SWAT					Bonferroni	
		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
(I) MSN	(J) MSN				Lower Bound	Upper Bound
1	2	6.229	2.016	.021	1.295	11.162
2	1	-6.229	2.016	.021	-11.162	-1.295

Based on estimated marginal means. The mean difference is significant at the .05 level.

3.1.2 PILOT ANALYSIS

Figures 3 and 4 show the mean SWAT values for the pilots (flight crew) for mission, and mission and freeze point respectively. Unlike the crew, OSO or DSO, the Pilot's average SWAT score was greatest for Mission 2 (19.01 vs. 22.49). Likewise the pilot's greatest average SWAT score was for Mission 2, freeze point 3 (33.23). More indices of central tendency and dispersion are available in Appendix 8, Table 2 and correlation coefficients in Appendix 8, Table 6. There was a significant correlation between SWAT and freeze point ($p<0.01$).

The pilot SWAT data was analyzed by repeated measures MANOVA for mission and freeze point. No significant main effects or significant interactions were found (Appendix 9, Table 4). As with the crew analysis, B-1B experience was treated as a between subjects variable but was not found to be significant ($p>0.05$).

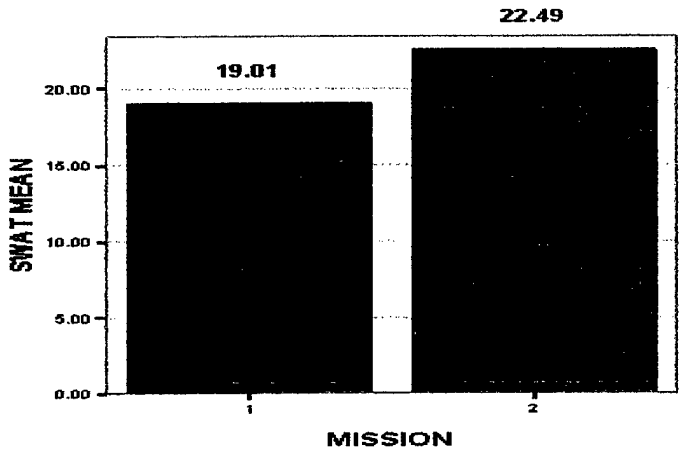

Figure 3. SWAT MEAN – FLIGHT CREW

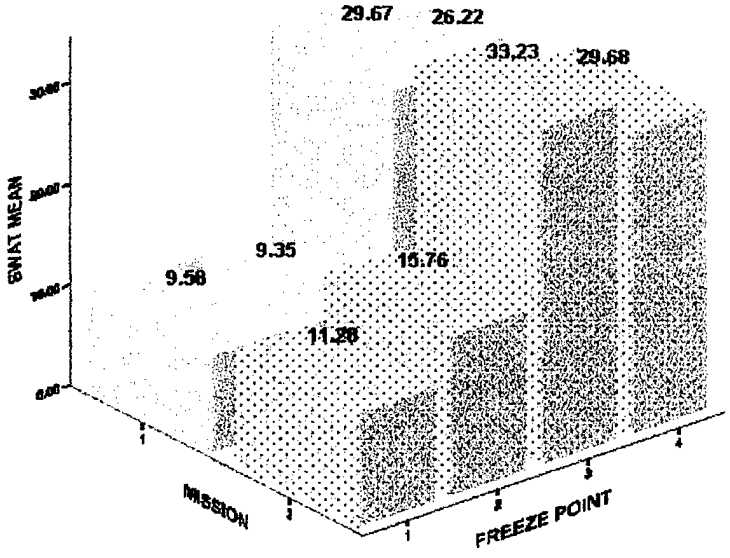

Figure 4. SWAT MEAN BY MISSION AND FREEZE POINT – FLIGHT CREW

3.1.3 OSO ANALYSIS

Figures 5 and 6 depict the SWAT mean values for the OSO mission, and mission and freeze point respectively. The greatest average SWAT score was for Mission 1 (40.45 vs. 20.43) and Mission 1, freeze point 4 had the largest average SWAT value (51.76). Reference Appendix 8, Table 3 for additional indices of central tendency and dispersion and Appendix 8, Table 7 for correlation coefficients. There was a significant negative

correlation between SWAT and mission, and a significant positive correlation between SWAT and freeze point ($p<0.01$).

The OSO SWAT data was analyzed with a repeated measures MANOVA for mission and freeze point. The MANOVA was significant for mission main effects and freeze point ($p<0.05$, Appendix 9, Table 5). There was no significant interaction ($p>0.05$). For the test of within subject contrasts, mission and freeze point (linear contrasts) were significant ($p<0.05$, Table 3). B-1B experience was examined as a between subjects variable but was found not to be significant ($p<0.05$).

Given that the OSO MANOVA was significant, a more detailed analysis using the mean difference was accomplished and showed a significant difference for mission ($p < 0.05$, Table 4). None of the freeze point pair-wise comparisons were significant. However, note that the pair-wise comparison for freeze point 1 and 4 was very close to achieving significance ($p=0.056$, Table 5). Sample Eta Squared and generalized population Eta Squared values are reported in Table 3.

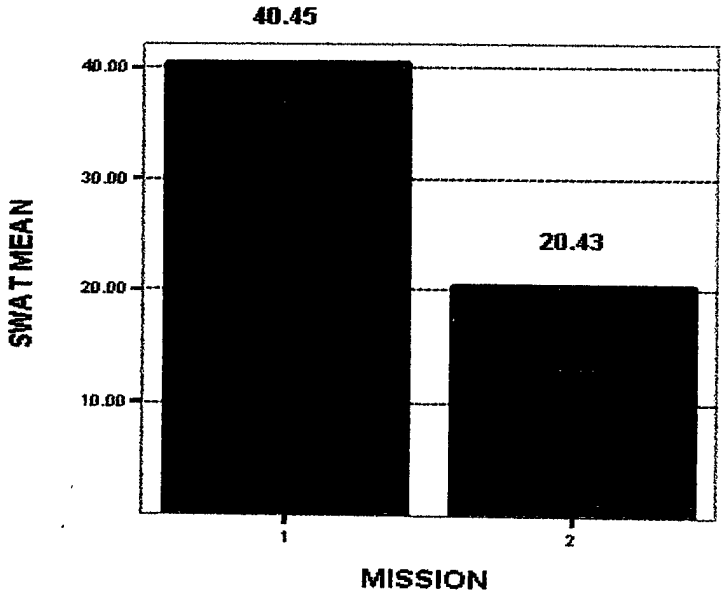

Figure 5. SWAT MEAN - OSO

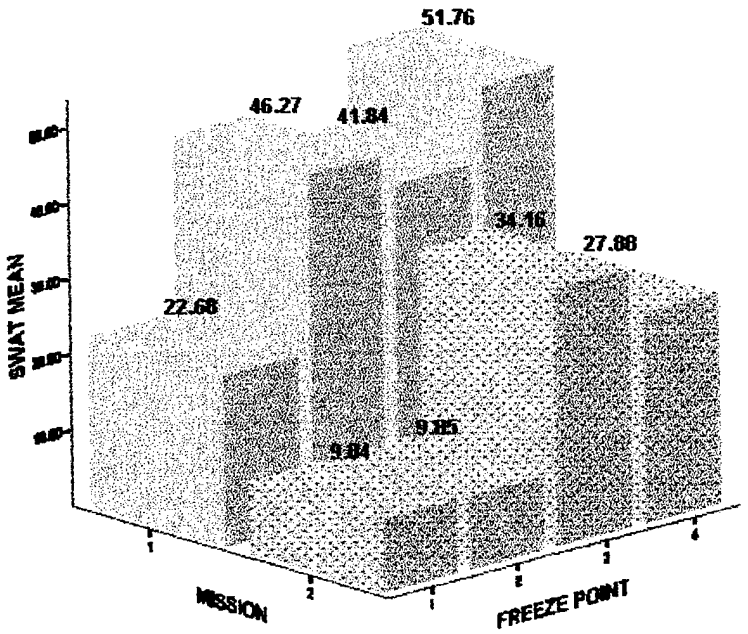

Figure 6. SWAT MEAN BY MISSION AND FREEZE POINT - OSO

TABLE 3. TESTS OF WITHIN-SUBJECTS CONTRASTS: MISSION AND FREEZE POINT - OSO

SWAT Source	MSN	FRZPT	Type IV Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Estimated Population Eta Squared
MSN	Level 2 vs. Level 1		11949.176	1	11949.176	21.447	.019	.877	.859
FRZPT		Linear	1459.147	1	1459.147	27.627	.013	.902	.888
		Quadratic	125.741	1	125.741	.949	.402	.240	-
		Cubic	6.953	1	6.953	.053	.833	.017	-

TABLE 4. PAIRWISE COMPARISONS: MISSION - OSO

SWAT					Bonferroni	
		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
(I) MSN	(J) MSN				Lower Bound	Upper Bound
1	2	23.000	4.966	.019*	7.195	38.805
2	1	-23.000	4.966	.019*	-38.805	-7.195

*The mean difference is significant at the .05 level.
Based on estimated marginal means

TABLE 5. PAIRWISE COMPARISON: MISSION AND FREEZE POINT - OSO

SWAT						
		Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference [a]	
(I) FRZPT	(J) FRZPT				Lower Bound	Upper Bound
1	2	-12.900	7.971	1.000	-62.575	36.775
	3	-18.600	7.051	.467	-62.536	25.336
	4	-22.063	3.676	.056	-44.970	.845
2	1	12.900	7.971	1.000	-36.775	62.575
	3	-5.700	7.183	1.000	-50.462	39.062
	4	-9.163	5.663	1.000	-44.453	26.128
3	1	18.600	7.051	.467	-25.336	62.536
	2	5.700	7.183	1.000	-39.062	50.462
	4	-3.462	3.692	1.000	-26.467	19.542
4	1	22.063	3.676	.056	-.845	44.970
	2	9.163	5.663	1.000	-26.128	44.453
	3	3.462	3.692	1.000	-19.542	26.467

Based on Estimated Marginal Means
a. Adjustment for multiple comparisons: Bonferroni

3.1.4 DSO ANALYSIS

Figures 7 and 8, respectively, depict the mean SWAT values for mission, and mission and freeze point. Consistent with the crew and the OSO, the largest average SWAT score was for Mission 1 (15.95 vs. 11.59). The largest average SWAT score for mission and freeze point was Mission 2, freeze point 3 (22.51). Not obvious from the graph, the average SWAT score for Mission 2, freeze point 1 was zero. Indices of central tendency and dispersion are shown in Appendix 8, Table 4 and correlation coefficients in Appendix 8, Table 8. There was a significant correlation between SWAT and freeze point ($p<0.01$).

The DSO SWAT data was analyzed with a repeated measures MANOVA for mission and freeze point. There were no significant main effects or significant interactions found ($p>0.05$, Appendix 9, Table 6). As with the crew analysis, B-1B experience was treated as a between subjects variable but was not found to be significant ($p>0.05$).

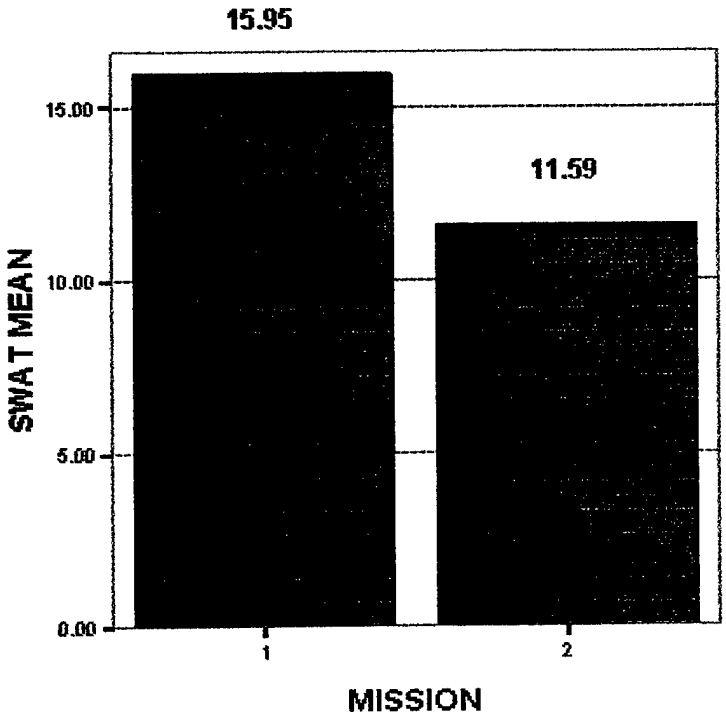

Figure 7. SWAT MEAN - DSO

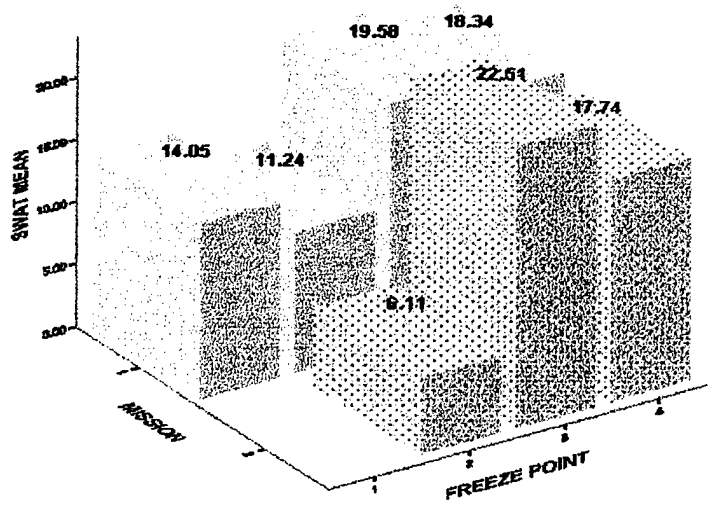

Figure 8. SWAT MEAN BY MISSION AND FREEZE POINT - DSO

3.1.5 SWAT DATA ANALYSIS SUMMARY

To summarize the areas of significant difference, Table 6 reports the SWAT mean difference and associated 95% confidence interval for the areas of statistical significance. The lower and upper bounds bracket the population value consistent with this study's observed data. The 95% confidence interval indicates replications of this study will reproduce in the population the same observed parameter within the specified bounds.

TABLE 6. SWAT: MEAN DIFFERENCE

* p< .05	CREW MISSION SIMPLE MAIN EFFECT AT FREEZE POINT 2	OSO MISSION MAIN EFFECT	OSO FREEZE POINT MAIN EFFECT
MEAN DIFFERENCE	6.229*	20.858*	23.000*
LOWER LIMIT 95% C.I.	1.295	8.261	7.195
UPPER LIMIT 95% C.I	11.162	33.456	38.805

3.1.6 DUTY

An artifact of the study had some WSOs performing the same duty (either OSO or DSO) for both missions, or performing a different duty for each mission. A separate analysis parsed out the impact of duty. Duty defined whether the WSO flew both missions as a dedicated OSO or DSO, or flew one mission as the OSO and the second mission as the DSO (flexible). Using a Univariate ANOVA, SWAT was analyzed across subjects. Subjects were identified as either a dedicated OSO, dedicated DSO or performed both functions (flexible). The Univariate ANOVA for the three groups was significant ($p < 0.05$, Table 7). Also, the pair-wise comparisons were significant ($p < 0.05$, Table 8) showing that workload, in general, is greatest for the OSO, as expected, and that the difference between dedicated and flexible groups was due to the greater OSO workload. When combining the OSO and DSO dedicated subjects into one group and comparing that group to the flexible group, duty was not significantly different between the two groups (Table 9). Therefore, it is unlikely duty impacted the results noted in the previous sections.

TABLE 7. UNIVARIATE ANOVA – DUTY DEPENDENT MEASURE: SWAT WSO

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9839.423	2	4919.711	10.088	.000
Intercept	59628.748	1	59628.748	122.271	.000
DUTY	9839.423	2	4919.711	10.088	.000*
Error	59984.426	123	487.678		
Total	130860.660	126			
Corrected Total	69823.849	125			

* $p < 0.01$

TABLE 8. PAIRWISE COMPARISONS: WSO DUTY

Dependent Variable: SWAT

(I) DUTY	(J) DUTY	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	20.717	4.938	.000	8.732	32.703
	3	3.803	4.774	1.000	-7.785	15.391
2	1	-20.717	4.938	.000	-32.703	-8.732
	3	-16.914	4.774	.002	-28.502	-5.326
3	1	-3.803	4.774	1.000	-15.391	7.785
	2	16.914	4.774	.002	5.326	28.502

Based on estimated marginal means
The mean difference is significant at the .05 level.

TABLE 9. UNIVARIATE ANOVA – DUTY WSO DEDICATED VS WSO FLEXIBLE

Dependent Variable: SWAT

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1255.126	1	1255.126	2.270	.134
Intercept	61232.278	1	61232.278	110.733	.000
NEWGRP	1255.126	1	1255.126	2.270	.134
Error	68568.722	124	552.974		
Total	130860.660	126			
Corrected Total	69823.849	125			

3.2 SITUATIONAL AWARENESS DATA ANALYSIS

Situational Awareness was defined as a binary event - either they had it or they didn't. This binary data was generated by comparing the answers given to the Situational Awareness question during each of the 4 mission freeze points, and comparing the answer to reality (most times with a tolerance band). If crewmember's answer was within the reality band, the crewmember had Situational Awareness. See Table 10 for the SA Measures Tolerance Bands.

TABLE 10. SA MEASURES AND TOLERANCE BANDS

Pilot & Copilot SA Measures	DSO SA Measures	OSO SA Measures
Own Ship	**Own Ship**	**Own Ship**
Heading (±3°)	**ASQ-184 Mode** (RMP AUTO, RMP SEMI, PREBRIEF, RMP MAN)	**WCMD/JDAM** (Type/Location, Status, Target SN, Key status
Altitude (±300')	**ALR-50 Status/Mode** (Decoy Status, Left/Right Launcher, Transmitting, Auto/Man Technique)	**Hung Stores** (Bay 1, 2, 3, Inboard/Outboard – 1 or 3 Hung and/or Blocked)
Air Speed (±5 kts)	**ALR-56M Mode** (Lethal/Normal)	**Bearing/Range from A/C to Cursor** (BRA)
	Low Band On-Board Jammer Status (Generating RF [Rays], Degraded Mode [Brackets])	**ILST Status/Mode**
		Own Ship Location (Lat/Long [hours, minutes])
Environment	**Environment**	**Environment**
Threat Azimuth (±5°)	**Threat Status** ("New Guy" Flash, Priority Diamond for Float, Sequenced, and Select Audio, Flashing Launch Box, Jammed/Not Hammed Emitter [dim on Battle Management Page])	**Relative LAR Location** (Heading, Right/left Cross Track Range, JDAM Constrained ["in-zone"]/Unconstrained ["in-range"], WCMD SFW "in-zone/"in-range")
Threat Type/Status (Zero)	**Threat Type** (SAM, AAA, MIG)	**Time to Wypt/TGT** (±10 sec)
Time to Wypt/TGT (±10sec)	**Threat Priority** (1, 2, or 3)	**Targets** (TGTs Enabled/All, TGT SN, Type, Range/Zone Status, Delivery Status [AVL/REQ])
Bearing/Heading to TGT (±5°)	**Threat ALR-56M** Azimuth (AOA ±5°)	**New TGT Location** (Lat/Long [hours, minutes])
	Threat ALR-56M Range (± 1Nm)	

In the Pass/Fail section of the Crew response spread sheets Pass = 1, Fail = 0

TABLE 11. SITUATIONAL AWARENESS DATA TABLES

Pilot SA Data - Mission 1 (UTTR)				
Crew Number	Freeze Point			
	1 Time to TGT	2 # Hung Weapons	3 # Weapons released	4 Radar mode
1	No data	No data	No data	No data
2	No data	No data	No data	No data
3	0	1	0	1
4	0	0	1	1
5	0	0	1	1
6	0	0	0	0
7	0	0	1	1
8	0	0	0	0
Summary	**0 of 6 with SA**	**1 of 6 with SA**	**3 of 6 with SA**	**4 of 6 with SA**

Pilot SA Data - Mission 2 (Powder River)				
Crew Number	Freeze Point			
	1 Tanker Bearing	2 # Weapons remaining	3 Ownship heading	4 Time to Waypoint
1	No data	No data	No data	No data
2	0	0	1	1
3	0	1	0	1
4	0	1	0	1
5	0	0	0	1
6	1	1	0	1
7	0	1	0	1
8	0	1	0	1
Summary	**1 of 7 with SA**	**5 of 7 with SA**	**1 of 7 with SA**	**7 of 7 with SA**

TABLE 11. continued.

Co-pilot SA Data - Mission 1 (UTTR)				
Crew Number	Freeze Point			
	1 Heading to TGT	2 Altitude	3 Time to go	4 Active threat status
1	No data	No data	No data	No data
2	No data	No data	No data	No data
3	1	1	0	1
4	0	0	0	0
5	0	1	0	1
6	0	0	0	1
7	0	0	1	1
8	1	0	1	1
Summary	**2 of 6 with SA**	**2 of 6 with SA**	**2 of 6 with SA**	**5 of 6 with SA**

Co-pilot SA Data - Mission 2 (Powder River)				
Crew Number	Freeze Point			
	1 Tanker altitude	3 Time to go	3 Ownship airspeed	4 Cross-track
1	No data	No data	No data	No data
2	0	0	1	0
3	1	0	1	0
4	1	0	1	0
5	1	0	1	0
6	1	1	0	0
7	1	1	1	1
8	1	0	0	0
Summary	**6 of 7 with SA**	**2 of 7 with SA**	**5 of 7 with SA**	**1 of 7 with SA**

OSO SA Data - Mission 1 (UTTR)				
Crew Number	Freeze Point			
	1 Time to TGT	2 # Hung Weapons	3 # Weapons released	4 Radar mode
1	No data	No data	No data	No data
2	No data	0	No data	No data
3	0	0	0	1
4	0	1	1	1
5	0	1	1	1
6	0	1	1	1
7	1	1	0	1
8	0	1	0	1
Summary	**1 of 6 with SA**	**5 of 7 with SA**	**3 of 6 with SA**	**6 of 6 with SA**

TABLE 11. continued.

OSO SA Data - Mission 2 (Powder River)				
Crew Number	Freeze Point			
	1 Tanker Bearing	2 # Weapons remaining	3 Ownship heading	4 Time to Waypoint
1	No data	No data	No data	No data
2	0	1	1	0
3	0	0	0	1
4	0	1	1	0
5	0	1	1	0
6	0	1	1	0
7	0	0	0	0
8	0	1	0	0
Summary	0 of 7 with SA	5 of 7 with SA	4 of 7 with SA	1 of 7 with SA

DSO SA Data - Mission 1 (UTTR)				
Crew Number	Freeze Point			
	1 Threat type and number	2 # Decoy Status	3 # Threat range	4 Threat mode
1	No data	No data	No data	No data
2	No data	No data	No data	No data
3	1	1	1	1
4	1	1	1	0
5	1	1	0	1
6	0	1	0	1
7	1	1	1	1
8	1	1	1	1
Summary	**5 of 6 with SA**	**6 of 6 with SA**	**4 of 6 with SA**	**5 of 6 with SA**

DSO SA Data - Mission 2 (Powder River)				
Crew Number	Freeze Point			
	1 Ownship altitude	2 # Decoy status	3 Threat type	4 Number of threats
1	No data	No data	No data	No data
2	0	1	0	1
3	0	1	0	0
4	1	1	0	0
5	1	1	1	0
6	0	1	1	0
7	1	1	0	0
8	0	1	1	0
Summary	**3 of 7 with SA**	**7 of 7 with SA**	**3 of 7 with SA**	**1 of 7 with SA**

3.3 QUESTIONNAIRE DATA ANALYSIS

See Appendix 2.

All rating scales were:

a. Totally Acceptable
b. Very Acceptable
c. Somewhat Acceptable
d. Borderline
e. Somewhat Unacceptable
f. Very Unacceptable
g. Totally Unacceptable

An "a." was the high score of 7, and "g." was the low score of 1. A question's ratings were averaged across crewmembers and rounded to the nearest whole number. This whole number determined the final rating. For example, an average rating of 4.07, rounded to the whole number 4, meant that a "Borderline" rating was reported. Another example would be an average rating of 3.81 rounded to the whole number 4: this would also result in a "Borderline" rating. A rating frequency histogram is in Appendix 2 with each question.

The results of Rank Ordering potential upgrades are reflected in the order they are reported. That is, if the 1st item on the list in the questionnaire is "Data Link", then that item received the most votes, the 2nd item "Color Heads Down Display" came in 2nd, etc.

All crew comments are reported in Appendix 2 verbatim.

4.0 DISCUSSION

4.1 SWAT DISSCUSSION

At the crew level, there were no significant main effects for mission and freeze point; however, there was a significant interaction between mission and freeze point. More detailed analyses revealed that there was a significant difference in SWAT ($p<0.05$) between Missions 1 and 2 at freeze point 2. At Mission 1, freeze point 2, there was a JDAM hung store, and for Mission 2, freeze point 2 there was a WCMD bomb drop. The higher workload associated with Mission 1, freeze point 2 has implications for the more complex OSO task as noted below.

There were no significant findings for the Flight Crew (i.e., pilots & copilots). Although the B-1B ERS is a real time, high fidelity system, realistic combat mission conditions were not feasible for the study. For example, there was no visual system so the co-pilot did not scan the horizon with NVGs, or the accomplishment of periodic checklists was minimal. Also, the simulation took place under pristine conditions, that is, there was no severe weather or aircraft malfunctions. Based on the conditions during the test, the controls and displays that were available to the flight crew appeared to provide an acceptable interface such that workload was at an acceptable level. Pilot comments for improving the pilot-vehicle interface are reported in the questionnaire section (Appendix 2).

The major workload study findings occurred with the OSO. There was a significant difference in workload between Mission 1 (JDAM) and Mission 2 (WCMD) for the mission and freeze point MANOVA. Also, there was significant and strong Eta Squared or association between SWAT score differences in mission and freeze point that will generalize to the population. The linearity for freeze point indicates that workload increased as the mission progressed. The mean difference between missions indicates that the workload for Mission 1 (JDAM) was twice the workload for Mission 2 (WCMD) (40.45 vs. 20.43). The SWAT value of 40.45 represented an average mission workload value. Air Force Research Laboratory, (the SWAT developer), has determined that a group mean SWAT score of 40 represents a "red line" (i.e., it is an indicator that performance may start to degrade). Furthermore, the means indicate that the workloads associated with freeze points 2, 3, and 4 for Mission 1 (JDAM scenario) exceed the workload "red line" (46.27, 41.84, and 51.76 respectively).

The WSOs had their choice to be dedicated to one position or to switch stations. The majority of WSOs (10 versus 6) had a preference for one position over the other. There was concern that the option to change stations might impact the crew-level SWAT scores. The ANOVA comparing the three groups (OSO dedicated, DSO dedicated, and Flexible) found duty did make a significant difference in the SWAT scores. In further analysis, combining the "OSO dedicated" and "DSO dedicated" into one group and comparing it with the "Flexible" group resulted in no significant difference ($p>0.05$). This result

alleviates any concern that duty impacted the crew SWAT scores; however, future study designs should consider restricting the WSO to one station to improve the power of the study.

This study did not address system performance (i.e., bombing accuracy, skill in avoidance of lethal threats, etc). The Block D, E, and F displays and their interfaces were evaluated, not the system's effectiveness. Furthermore, combat conditions were not part of the simulation and, in particular, the flight deck did not accomplish their typical in-flight checklist procedures, and vigilance activities.

The study data results indicate that for the crew level, there is no significant difference in workload between the JDAM and WCMD missions; however, there is a significantly higher workload associated with freeze point 2. For the JDAM mission, freeze point 2 was a JDAM hung store.

Looking at the workload of each crew position, the study data suggests that the flight crew (pilot and co-pilot) and the DSO workload levels are acceptable. The OSO has the highest workload and it may exceed an acceptable workload capacity. This conclusion is in agreement with the questionnaire responses. Although the pilots made recommendations for improving the CDU and recommended other necessary information to improve their flight deck situation awareness, in general, the results found that the Pilot Vehicle Interface (PVI) was acceptable. The same is true for the DSO. For the most part, the DSO's controls and displays were acceptable. Unlike their crewmates, the OSOs rated their displays (JDAM, WCMD, and LAR displays) marginal to somewhat acceptable, as expected, given the complexity of the OSO tasks.

Based on the workload results of this study, the OSO's workload is excessive for the JDAM scenario. Starting with freeze point 2 (JDAM hung store) until the end of the mission, the OSO's workload as indicated by the SWAT scores, exceeds recommended limits. Control and display improvements to the Block E JDAM and LAR displays are recommended to reduce the OSO's workload. The biggest return on invested acquisition dollars will come from upgrades for the OSO. It should be noted, however, that changes to the OSO station may impact the DSO as well.

4.2 SITUATIONAL AWARENESS (SA) DISCUSSION

4.2.1 PILOT & COPILOT SITUATIONAL AWARENESS DISCUSSION

Collapsing across Pilots, Copilots, Freeze Points, and Missions, the subjects had Situational Awareness only 45% of the time. This may be attributed to the fact that this was a simulation and the pilots and copilots sometimes seemed bored or apathetic (e.g., two crews "crashed" the aircraft during a mission). Further, they might have been under-challenged by the simulator (e.g., only CDU was "new", no motion base, visual system, use of check lists, in-flight emergencies, etc.). And lastly, the SA Questions may have been inappropriate or meaningless for the activity associated with that freeze point. Otherwise the SA scores in Table 10 speak for themselves.

Inappropriate SA questions are perhaps a major flaw in the SAGAT technique in the full mission simulation arena. Questions asked at the freeze point are supposed to be randomly chosen from a very long list of possibilities. Experimentally, this is good technique, but a randomly chosen question may be totally meaningless in the context of that particular mission/freeze point. Therefore, if the crew member lacks SA, is this due to a system design flaw, such as a lack of appropriate SA information, or to a question that is meaningless when taken in the mission/freeze point context? In other words, there is no point in knowing that particular SA information at that point in time. The study attempted to reconcile this conflict by trying to give contextually meaningful SA questions, but still trying to quasi-randomly select the SA question. It is believed that this was only partially successful and may account for some unknown portion of the "lack of SA". Similar comments may apply to the OSO and DSO SA scores.

No meaningful Situational Awareness data could be gotten from either the first crew's and sometimes the second crew's, Pilots and Copilots. This was because of:

a. B-1B ERS software problems, such as a proper (software) triggering of freeze points,
b. A lack of instructional emphasis on strictly meeting the Estimated Time of Arrival (ETA) for the waypoints. The freeze points were automatically time triggered with a clock start time based on the unfreezing of the simulator (i.e., simulator "takeoff"), and
c. Improper formulation of Situational Awareness questions that were meaningful in the context of the current mission freeze.

4.2.2 OSO SITUATIONAL AWARENESS DISCUSSION

Collapsing across Freeze Points and Missions, 48% of OSOs had SA.

No meaningful Situational Awareness data could be obtained from the first two crew's OSOs for the same reasons as discussed in paragraph 4.2.1 PILOT & COPILOT SITUATIONAL AWARENESS DISCUSSION.

4.2.3 DSO SITUATIONAL AWARENESS DISCUSSION

Collapsing across Freeze Points and Missions, 65% of DSOs had SA.

No meaningful Situational Awareness data could be obtained from the first crew's DSOs for the same reasons as discussed in paragraph 4.2.1 PILOT & COPILOT SITUATIONAL AWARENESS DISCUSSION.

4.3 QUESTIONNAIRE DISCUISSION

4.3.1 PILOT AND COPILOT RESPONSES

According to the questionnaire, 14 out of 16 pilots and copilots thought some changes need to be made to the CMNS CDU. The acceptability of the CDU Flight Plan interface was rated as borderline. Internal crew and external world coordination, and flight situational awareness were rated as somewhat unacceptable. Targeting and tanker rendezvous information was rated borderline. Out of 12 choices, the top-three rated items were Data Link, HUD, and Color Heads Down Displays in terms of operational usefulness for future Block upgrades.

4.3.2 OSO RESPONSES

The WCMD and JDAM display formats were rated as borderline. ILST was rated as very acceptable. LAR displays and targeting information were rated as somewhat unacceptable. Eight out of eleven OSOs were able to use the LAR display to steer to the upcoming weapons LAR(s). Only four out of ten OSOs were able to follow the sequence of weapons releases using the LAR display. Inter-Crew Coordination and Communication, and Coordination with the outside world was rated as somewhat acceptable. Target Situational Awareness was rated borderline. The top-three out of seven most operationally useful improvements would be Data Link, Color Heads Down Display, and Moving map (i.e., the same as the DSO).

4.3.3 DSO RESPONSES

The ASQ-185 RWR Controls and Displays were rated somewhat acceptable. The FOTD CDU, the ALR-56M, inter-crew coordination, EW MFD formats, and Threat Situational Awareness were rated very acceptable. Communications, the CDU and ASQ-184 Combination, and RFS/ECM panel were rated somewhat acceptable. The top-three out of seven operationally useful future upgrades were Data Link, Color Heads Down Displays, and Moving Map (i.e., the same as the OSO).

4.4 GENERAL LAUNCH ACCEPTABILITY REGION (LAR) DISCUSSION

a. From SWAT we can see:

   Based on the workload results of this study, the OSO's workload is excessive for the JDAM scenario. This excessive workload is significantly compounded by a hung store. Starting with freeze point 2 (JDAM hung store) until the end of the mission, the OSO's workload, as indicated by the SWAT scores, exceeds recommended limits.

b. From the questionnaire we can see:

The WCMD and JDAM display formats (e.g., D & E Pages) were rated as borderline. LAR displays (EB Page) and targeting information were rated as somewhat unacceptable. Eight out of eleven OSOs were able to use the LAR display to steer to the upcoming weapons LAR(s). Only four out of ten OSOs were able to follow the sequence of weapons releases using the LAR display. Target Situational awareness was rated borderline.

c. From Observation and the Video Tape we can see (see TABLES 12.A. & 12.B.):

TABLE 12.A. UTTR – LAR OBSERVATIONS

CREW	MSN	Bomb Run	LAR Time per Bomb Run (sec)	ON/OFF Black Line	Actual JDAMS Dropped	Planned JDAMS	Notes
1	1	1	122	ON	9	9	3 Hung Weapons
		2	192	OFF	0	8	Missed LAR
		3	0	ON	0	2	Active Weapon Select
2	1	1	6	ON	0	0	ERS Malfunction
		2	4	OFF	0	0	ERS Malfunction
		3	16	ON	0	0	ERS Malfunction
3	1	1	0	OFF	10	12	Missed LAR
		2	128	OFF	0	8	Missed LAR
		3	54	ON	0	2	Active Weapon Select
4	1	1	8	OFF	12	12	Good use of Target Summary/LAR
		2	38	OFF	8	8	Good use of Target Summary/LAR
		3	13	ON	2	2	
5	1	1	33	ON	12	12	
		2	50	OFF	8	8	Excellent use of LAR
		3	0	ON	1	1	
6	1	1	1	OFF	12	12	
		2	0	OFF	0	8	Hung Store added to lack of SA
		3	0	ON	0	2	Passed LAR working Hung Store
7	1	1	0	ON	12	12	
		2	15	OFF	6	6	Hung Store allowed 6 for Drop
		3	0	ON	2	2	
8	1	1	46	ON	12	12	
		2	105	OFF	6	6	
		3	35	ON	0	2	OSO was working Hung Store
			Mean Time 36.08 per run	13 of 24 ON 54%	Total 112	Total 146	
			Range = 0 to 192		On Line 50	On Line 56	
					Off Line 62	Off Line 90	
					Off Line 76.70%	On Line 89.30%	

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TABLE 12.B. POWDER RIVER – LAR OBSERVATIONS

CREW	MSN	Bomb Run	LAR Time per Bomb Run (sec)	Actual WCMDs Dropped	Planned WCMDs	Notes
1	2	1	122	0	1	ERS Malfunction
		2	192	0	1	ERS Malfunction
		3	0	0	1	ERS Malfunction
2	2	1	6	0	1	ERS Malfunction
		2	4	0	1	ERS Malfunction
		3	16	0	1	ERS Malfunction
3	2	1	41	1	1	
		2	0	1	1	
		3	14	1	1	
4	2	1	14	1	1	
		2	2	1	1	
		3	0	1	1	
5	2	1	1	1	1	
		2	10	1	1	
		3	0	1	1	
6	2	1	30	1	1	
		2	46	1	1	
		3	29	1	1	
7	2	1	1	1	1	
		2	0	1	1	
		3	6	1	1	
8	2	1	46	1	1	
		2	105	1	1	
		3	35	1	1	
			Mean Time 30 per run Range = 0 to 192	18 Due to Malfunctions	24	

1) The LAR was used an average of 33 seconds per bomb run for the three JDAM and the three WCMD bomb runs. The LAR usage range was zero to 192 seconds per bomb run. For 12 of 48 or 25% of the bomb runs, the LAR was not used by the OSO at all.

2) The OSO used the LAR only briefly before turning to other more important pages such as the Weapons Summary (D Page) or to the Target Summary page (E page).

3) All six bomb runs were at 24,000 feet MSL. At that altitude, no matter how far the crew got off of the planned route or "black line", it seemed that,

   a. as long as they were generally heading for the target steerpoint,
   b. and the target was a horizontal target (in this study there were no vertical targets),
   c. and the crew hadn't already flown completely through or beyond the LAR,

   Then LAR was always achieved.

4) It seemed to greatly help the OSO if the DSO stepped in to help the flight deck crew navigate while the OSO dealt with the hung store. Further, it seemed to help considerably if the OSO looked at the DSO's "stick map" on the TSD to keep general situational awareness of the aircraft's navigational situation.

5) Overall, the LAR display was beneficial when used properly in this simulation. During testing, the LAR display (EB page) was used between 0 and 192 seconds per bomb run with an average of 33 seconds per bomb run. During these runs, it was noted that under use as well as over use tended to negatively impact bombing performance. It was felt the crew's best performances were shown when the majority of information was taken from the Target Summary (E page) page while incorporating the LAR information for fine-tuning their bomb run. It was noticed, however, that there were times when OSO information was limited and resulted in rapid decline in OSO situational awareness (SA). This situation was mostly prevalent during multi-tasking such as navigation to bomb run combined with trying to resolve a hung store. In these cases, not only was the decline in SA rapid, but the process of regaining SA was extremely slow. On one occasion, the OSO was so disoriented that the crew had navigated past the 3rd bomb run before the OSO even realized that they had not dropped any weapons on the second bomb run. Next are some of the factors that contribute to the OSO's lack of SA.

6) Near-Mode-Ranging - While navigating to the LAR while in far-mode-ranging, the Target Summary (E page) page shows an estimated time to achieve LAR. However, when switching to near-mode-ranging, the target

summary gives actual time to achieve LAR. In order to get this actual time the aircraft must be headed towards the LAR. If the aircraft is flown off the "black line", then the time to go (TTG) to LAR reverts to a default value of 59:59. This signifies the max value of TTG of 59 minutes and 59 seconds. As a result, the OSO is left without half of the needed bombing information (TTG and Heading) during a critical phase of flight. On several occasions, while inbound to the target, the Pilot asked the OSO what the TTG to LAR was and if they were off the "black line". Invariably the OSO's answer was "I don't know".

7) Another function of near-mode-ranging raises some concern. When the aircraft enters the LAR, the TTG changes from time to achieve LAR to time to exit LAR. The only information showing this shift is a RANGE/ZONE indication. Although the information is available, it is not immediately obvious. On a few occasions, when the crew was turning back towards the "black line", the turn placed them into the LAR and the TTG indication changed from 59:59 to the actual time to exit the LAR. The OSO, however, interpreted this as time to achieve LAR and was surprised when the bay doors started to open and bombs dropped.

5.0 RECOMMENDATIONS

5.1 LAUNCH ACCEPTABILITY REGION (LAR) RECOMMENDATIONS

Control and display improvements to the Block E JDAM and LAR displays are recommended to reduce the OSO's workload. The biggest human factors return on investment will come from upgrades for the OSO.

a. An improved LAR display (EB Page) is needed, which gives more information about the LAR. The "LAR bars" only give general relative position, yet yield no Time To Go (TTG) or Distance information. As a result, the usefulness of the EB page for navigational/horizontal situational awareness is very limited.

b. Improved targeting information is needed. The target summary page (E Page) needs distance and time information at all times. When the aircraft is steered off of the "black line" in near mode ranging, the OSO looses all distance and time information to go to LAR, leaving only a heading value. This heading value only gives guidance to the Target steerpoint and not to the "mouth" of a LAR. This lack of information results in a significant loss of navigational/horizontal situational awareness at a critical time for the OSO.

c. On the E Page, when near mode ranging changes from far mode, if aircraft is not pointed towards LAR (i.e., off the "black line"), TTG changes from Actual Time to the default value of 59:59 minutes. Give Estimated Time to LAR, not default, when going from far to near mode ranging. Display Estimated TTG in reverse highlight (or in some other distinct way) to distinguish it from Actual TTG.

5.2 BASELINE STUDY RECOMMENDATIONS

a. Improved hung store training is needed for OSOs.

b. A Digital Bull, Bra, and Compass Rose should be added as soon as possible to the DSO's TSD.

c. WSOs have reservations about not being able to re-identify a threat if the defensive system is wrong. DSO threat re-identification capability should be added to the defensive system's controls and displays.

d. An ALR-56M Repeater should be added to the front flight station.

e. There seems to be a tendency for WSOs to treat JDAMs and WCMDs as "stand-off" weapons and not as enhanced accuracy weapons. This may stretch the capabilities of the weapons and associated controls and displays to or beyond the limit. Thus, JDAM and WCMD weapon capability training should be given or improved.

f. A Data Link, HUD, and Color Heads Down Displays are the top-three rated items that should be included in future Block Upgrades for the pilot and copilot.

g. A Data Link, Color Heads Down Displays, and Moving Map are the top three rated items that should be included in future Block Upgrades for the WSOs.

h. During critical phases of a mission, OSO task saturation may be high. This is compounded by the fact that the OSO is responsible for navigation as a primary duty. A review of current WSO procedures should be made with an eye towards the DSO becoming more involved in the navigation tasks. This may alleviate a significant portion of the OSO's overall workload.

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APPENDICIES:

APPENDIX 1 – CREW SCHEDULE, BASE, AND DATA MISSION ORDER

DATE:	BASE:	MISSION ORDER:
9-10 June	Tinker AFB	1, 2*
10-11 June	Dyess AFB	2, 1
15-16 June	Robbins AFB	1, 2
17-18 June	Dyess AFB	2, 1
22-23 June	McConnell AFB	2, 1
29-30 June	Robbins AFB	1, 2
8-9 July	Dyess AFB	1, 2
12-13 July	Ellsworth AFB	2, 1

* Mission 1 = UTTR: Mission 2 = Powder River

APPENDIX 2 – QUESTIONNAIRES

B-1B Baseline Study Questionnaire

Crewman # _____

Date: _____

(Your Name, Rank, Unit/Base, Phone Number will be kept private and will not appear in any reports on this study.)

NAME: _____ RANK: _____ AGE _____

UNIT/BASE Address:

_____

_____

DSN NUMBER: _____ E-Mail Address: _____

1. A. Pilot/Copilot Experience

Current Qualified Aircraft: B-1B Number of Flying Hrs: Ave.: 1212.56
Range: 150-2600 hrs

Other Aircraft Flown: _____ Number of Flying Hrs _____
Other Aircraft Flown: _____ Number of Flying Hrs _____
Other Aircraft Flown: _____ Number of Flying Hrs _____
Other Aircraft Flown: _____ Number of Flying Hrs _____

Total Flying Hrs: Ave. 2122.56 Range: 371-3650 hrs:

This section reflects only PILOT responses.

2. B-1B Simulator Time: Yes: 16 No: 0

Type Sim: WST, CPT, Full Motion ERS, B-1B SB001B(?)
Number of Hrs: Ave. 218.44 Range: 50-700

Purpose: (e.g. Upgrade training for Block X): initial qual-copilot; upgrade-pilot/instructor FTU instructor; Initial/recurrent/upgrade training; Training and as instructor; Mission qualification; Training and unit currency; Standard schoolhouse training and unit sims.

3. **Have you had previous B-1B Block D, E and/or F experience?** Yes: 4 No: 12

If yes, what aircraft/simulator(s)? B-1B Block D Number of Hrs _____

4. **Have you had any AFMSS Training?** Yes: 7 No: 9

5. **Have you had any training on GMTI?** Yes: 1 No: 15

6. **Have you had any training on JDAM?** Yes: 6 No: 9 No response: 1

7. **Are you familiar with Launch Acceptability Regions (LARs)?** Yes: 10 No: 6

8. a. **Have you ever participated in any B-1B studies or flight tests?** Yes: 7 No: 9

b. **If yes, describe:**
- WST software test;
- 10FLTS flight-test missions;
- PBAR for BDU-33;
- JSEAD/Live-EX - Green Flag 97-3;
- Weapons delivery;
- Block D initial controls and display (human factors);
- Block D TD&E
- Assigned to B-1 operational test unit, tested Blocks B, C and D

I. Pilot & Copilot Section

1. a. Does the Control Display Unit **(CDU) need any changes**? Yes14 No1
1 no response.

b. If yes, describe:

- Nav function for TAC emulation does not operate. Defeats briefed purpose of divert scenario. In Fplan cannot scroll to previous pts. Once Dir. "_" is selected, must manually select Fplan to get steering
- Not totally representative of Block D modified acft. For this test - comm package OK. Nav - doesn't work - not TAC emulation - if try to input ident. - kicks to window mode. STR page works OK. Can input coordinate change to flight plan page + (and?) go DIR TO. index for POWER PG CK. MASTER PWR ON ok. Everything else does not need to work for this test.
- See # 2
- All CDUs should be connected by a data bus!!! Should have "what if" sequence capability (i.e. what if I go direct to this point, how will this affect my timing, track, target without effecting the ins. track.
- Move Eng. Start switches toward firewall away from CDU, or put CDU next to firewall. Needs to be integrated into aircraft
- Can't tell at this point
- Have one CDU for each pilot
- Need hour/min/sec on ETA, now just hr/min ETA - 60=00 now - need 00 ex. 1900=1860
- Fix the parallax error. Change pages so that it displays the D# you're going to on the steer page
- XTRK L 3.0nm should mean that you 3nm left of track, instead this system says that you are 3nm right of centerline, very confusing. ETA should include seconds to go.
- Need seconds on ETO on STR page
- Color would be nice
- I feel that the ETA display should include seconds. When you are trucking along at 8 to 9 miles a minute, it would be great to just look down and see if you are early or late (to the second) instead of doing the needed math (carry over whole minutes). Pilots want to know if what they are doing with get them to the target/destination on time
- To/From switch for digital bull
- To make the VSD heading marker work I had to sequence to the steer point on the CDU
- I need to be able to re-name the steer points
- Needs to be able to display Bullseye Bearing/Distance in addition to the current steerpoint

2. Rate the acceptability of the CDU **Flight Plan Interface** *(Circle one)*:

Average Rating: 4.07 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	4
c. Somewhat Acceptable	3
d. Borderline	0
e. Somewhat Unacceptable	6
f. Very Unacceptable	2
g. Totally Unacceptable	0
	1 no response

Comments:

- See Above
- Can input flight plan change ok
- Add TTG or ETA to each point or flight plan page
- The pilots need to monitor closely the CDU flight plan. It does not always sequence automatically
- See above; and more CDU FWD away from the throttle quadrant.
- Integrate
- N/A – this was not about the CDU –did not get a chance to evaluate the entire CDU capability/T.F. interface
- Add current waypoint # to FPI page
- not attached to avionics
- Did not integrate with flight plan enough to rate
- Some integration with WSO would be nice, however not mandatory
- Would be good to interface with NAVs head(?). Suggest the option of having the OSO update the pilot's CDU

3. Rate the acceptability of the **Inter-Crew Coordination** *(Circle one)*:

Average Rating: 3.81 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	4
c. Somewhat Acceptable	2
d. Borderline	2
e. Somewhat Unacceptable	3
f. Very Unacceptable	5
g. Totally Unacceptable	0

Comments:

- Required much cockpit chatter to fill in SA holes
- More experienced crew allows better SA – information flow was good to help diagnose sim "isms", help trouble shoot problems.
- LAR presentation to pilots should be added to minimize comms.
- Pilots need better idea where LAR is and how maneuvers affect LAR
- The front station has actually lost SA - no indication when weapons release is about to/is happening
- Presentation: No one has a good understanding of when the weapons are releasing, how many have released? When were cleared to maneuver.
- need to integrate CNMS with ACU
- way too much talking, could interfere with radio communications
- CPT has limitations such as WSO displays for bank and altitude inoperative - makes for confusion.
- The aft station needs to be able to work the CNMS CDU from the aft station and also see what the pilots are doing, so we are in the same sheet of music.
- The limited SA requires additional (from present day) crew coordination. More chatter.
- Need to have common displays which will allow less interphone chatter

4. What changes, if any, might be made to improve crew coordination?

Comments:

- More information available and a better crew pre-brief so as to know what to expect during bomb runs. Understanding this is a limitation of the sim profile
- Make sure crew talks briefly about mission prior to going into box. Ensure flight plan reviewed - what configuration are you going fly, crunch points, options, potential problems, etc.
- Threat display & Bull information displayed in front station
- Digital Bull information on the pilot's VSD would be outstanding improvement; just 2 numbers (bearing and range of the B-1B to the Bull) would be extremely helpful to pilots and would cut down on inter-cockpit communication.
- RWR, LAR presentation to pilots
- Integrate CDU - Put moving LAR superimposed over TA display with appropriate ranges
- Block D has no LAR information for front or back i.e. unless we turn at the target, we may not know if we are in/near the LAR i.e. off-axis release planning. Block E/F still does not give the pilot station any clue to when a weapon is about to release. No way to back-up the WSOs.
- Modify/replace SMS panel (with MFD) to display number of weapons being released. TTG to 1st release, indicate last release. The MFD should also have a RWR function, weather radar page.
- RWR up front. Moving map up front
- Add moving map display
- Direction/timing/and distance to LAR on bottom center of VSD would aid pilot SA, and eliminate unnecessary comms during critical phases of flight as well as adding a RAW repeater scope. Along with a separate Bullseye repeater for pilot and copilot, capable of low-color weather radar
- Training on system at each station. Nice to know what information available, LAR information
- Allow NAV to update pilot's CDU
- Moving map with data link up front, so the pilots can see the threat, LAR, course line, etc.
- Improve SA for each station
- In the sim the VSD must be accurate
- OSO needs an ADI
- A phone call tone is unacceptable as a threat warning tone.

5. Rate the acceptability of the **Coordination with the Outside World** (e.g., radios) *(Circle one)*:

Average Rating: 3.38 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	0
c. Somewhat Acceptable	4
d. Borderline	1
e. Somewhat Unacceptable	4
f. Very Unacceptable	4
g. Totally Unacceptable	0
	3 no response

Comments:

- Due to limitations of sim, there was literally no outside comm. If we were part of a large package, as pre-briefed, there would be constant radio chatter that would have to be sorted through and reacted/responded to. This would be an SA builder and detractor depending on crew coordination required at that time
- ILST – improved SA is good. Continued troubleshooting of current Block D radio problems. Data link would be nice. Real time info is good.
- Need Accurate, quick ability to see threats and mission information (Link-16 type information). Also in dire need of a digital bull.
- Needs data link
- We really did not do any
- Unknown
- Not much work here in the sim
- Block D radios are unacceptable in trans/recp. Also must have digital bull at every position.

6. Rate the acceptability of the **Flight Situational Awareness** *(Circle one)*:

Average Rating: 3.56 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	0
c. Somewhat Acceptable	4
d. Borderline	1
e. Somewhat Unacceptable	5
f. Very Unacceptable	3
g. Totally Unacceptable	1
	2 no response

Comments:

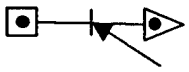
- Limitations of sim profile and see above
- Info flow was pretty good between stations. ILST info was good for tanker rendezvous.
- See # 5. Also, front seat workload would be drastically reduced by adding MFDs and a HUD. The B-1 has very poor visibility and SA is made worse by having to keep head down.
- A RWR scope for pilots would be very helpful for situational awareness. It could currently go where the Aux, Master Caution Panel is and the Aux panel could go on the left side of the pilot's HSI so the co-pilot can see it also.
- Need RWR, SMS information to reduce crew communication
- Need moving map / data link / RWR / weapons data
- No moving map display or threat picture
- See comments for #4
- CDU increases SA 100%!
- I think CPT limitations were the problem
- Cross track is good, but a picture is worth 1000 words. It is nice to see if your ADF maneuver is going to work.
- As a pilot I am now almost totally out of the bombing SA loop. Any time you force crew coordination you limit the crew's ability to perform.

7. Rate the acceptability of the **Targeting Information** controls & displays (e.g., Launch Acceptability Region (LAR) *(Circle)*:

Average Rating: 4.47 (Highest score – 7; lowest 1)

a. Totally Acceptable	3
b. Very Acceptable	3
c. Somewhat Acceptable	1
d. Borderline	4
e. Somewhat Unacceptable	1
f. Very Unacceptable	1
g. Totally Unacceptable	2
	1 no response

Comments:

- Requires constant crew coordination OSO must give pilots a PAR to LAR. Pilots have No information as to heading and distance to LAR.
- No SA for pilot other than what he hears from OSO. In a cluttered radio environment (Red Flag) – unacceptable. Eventually need visual indication up front as to where you are in relationship to LAR and how to quickly to correct.
- Very difficult to visualize where and how to get to LAR
- Pilots have no SA on the LAR
- From pilot's perspective
- Need LAR where SRAM Safe and In Range (SAIR) was on bomb panel. ERS bomb nav panel for Bomb mode and VSD and doors need to work like airplane. Don't need master caution light upon bay selection
- Cannot tell if OSO is in bomb mode, if WIUs are powered. Block, pilots get a "Bomb" mode in USD when a target is selected and bomb mode is on. SMS panel give no SA except doors are open 99 goes out. In the heat of battle the pilots cannot help out the WSOs.
- No display / information up front.
- No SA at all - need LAR displayed on moving map and continually updated
- Need more LAR information, range, TTG
- see comments for #4
- If your IP to TGT is 

  but you actually get the weapon off here there is no reason to go to target. So this mission planning needs to be reconsidered
- There truly was none up-front; however there needs to be.
- Need LAR steering at front station

8. Rate the acceptability of the **Threat Information** (e.g., Threat Bearing) *(Circle one)*:

Average Rating: 3.87 (Highest score – 7; lowest 1)

a. Totally Acceptable	3
b. Very Acceptable	2
c. Somewhat Acceptable	1
d. Borderline	1
e. Somewhat Unacceptable	3
f. Very Unacceptable	2
g. Totally Unacceptable	2
	1 no response

Comments:

- Need audio
- Good DSO is important. Threat SA seemed to be pretty good for this test.
- See # 5
- See #6
- The addition of RWR to front station will enhance SA
- Still no SA / New guy tone – outstanding
- No display up front.
- Needs RWR up front. Need expendable control up front
- No information up front except interphone - too much likelihood of stepping on each other
- See comments for #4
- With ALR-56M repeater
- DSO did the work. He was good.
- Move threat repeater down below the Aux Caution panel on the pilot's side.
- Threat audio tone gives no capability to ID a threat with a visual RWR indication. Air-to-Air, Air-to-Ground, AQ, TT, IL?
  (Additionally, respondent indicated this as "e. Somewhat Acceptable" for simulator range and bearing and ID)
- Need to have front station threat info. To increase SA and decrease interphone chatter. -- Lives depend on it.

9. Rate the acceptability of **Tanker Rendezvous** (e.g., Inter-Leavened Search & Track (ILST) *(Circle one)*:

Average Rating: 3.69 (Highest score – 7; lowest 1)

a. Totally Acceptable	2
b. Very Acceptable	1
c. Somewhat Acceptable	1
d. Borderline	4
e. Somewhat Unacceptable	0
f. Very Unacceptable	2
g. Totally Unacceptable	3
	3 no response

Comments:

- Good to have info
- ILST – nice
- Pilots have no SA as to the benefits of ILST
- Unaware of ILST changes up front
- No difference/impact to pilots
- No display up front
- need to repeat information up front
- Problems with display should use CAF standard for display
- Cannot rate as a pilot. Comm from OSO was great
- From front station - sounded great
- Really could not see it from up-front in the sim.
- Add the capability to the front station
- Great capability - will be used for threat.

10. Rank Order (*Low = 1*) the following in terms of **Operational Usefulness:** For each write in what **Operation Shortfall/Capability** it addresses:

R.O. OPS Issue

Data Link _____ _____

- 18 hour Global Power - real-time updates
- Package integration/SA
- Absolute need for SA and last minute changes
- Package integration, Theater SA
- Time critical target attack

HUD _____ _____

- More SA, less head down time
- Great for human factors and clearing
- Takes place of limited VSD and add visual SA
- SA and targeting

Color Head Down Displays _____ _____

- MFD would allow replacement of SMS panel RWR
- Required moving map display
- More threat/nav/mission/radar information in flight
- Contrast, more intuitive information, CHEAPER!
- Common front/aft station displays

NVG Lighting _____ _____

- Shortfall - illum stix ineffective
- Current system has severe limitations
- Have to have, mission essential
- Makes NVG 100% useful as opposed to 75%
- Today's is less than adequate
- Night attack

FLIR _____ _____

- Precision weapons capability/GBUs/LGBs
- PGM capability
- Would be nice to have, more SA
- Whatever
- Precision weapon targeting

Helmet Mounted Display _____ _____

- Nice, but not mandatory
- Unless you get the weight down this could be BAD. NVGs are bad enough
- SA and targeting

Moving Map _____ _____

- Improves SA dramatically
- Could be used with color MFD
- LAR display, Digital bullseye, Datalink display all covered
- Lack of RTIC/displays

- Everyone's SA up 50% or more
- SA for all missions

Off-Board Mission Planning _____ _____

- Already exists
- Good for getting changes to crew on long missions
- All attack missions

On-Board Mission Planning _____ _____

- Must have with data link so we can actually use information
- Re-tasking
- Second best to off-board mission planning.
- Time critical target attack

Global Air Traffic Management (GATM) _____ _____

- Soon to be mandatory for certain nav tracks
- I don't even know what this is. I hear Kosovo was cluttered in the sky
- ?
- Global nav.

Digital Bullseye _____ _____

- Need immediate B/E for large force execution
- With moving map
- With pilot repeater scopes below airspeed for pilot and below altimeter for copilot
- Threat awareness / composite force package
- Pilot SA up 100%
- Lifeline (common ref.) for strike packages.

TSF Compare >>>>> _____ _____

Other _____ _____ _____

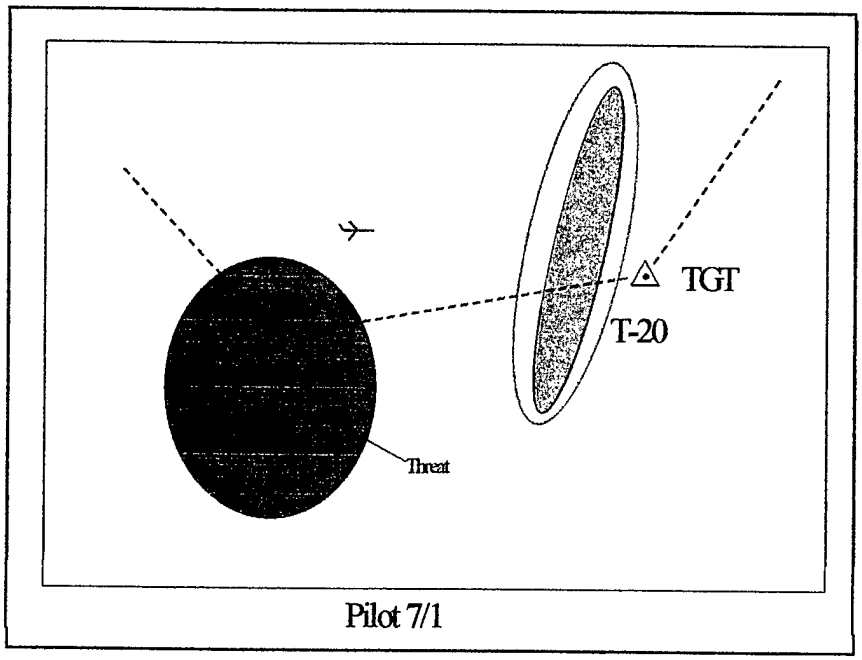
- Low Light TV
- RWR
- 4th generator
- RAW repeater for pilots
- Engines - for higher (40,000+ Alt) capabilities

11. After the B-1B Block D, E, and F Upgrades are completed, what will be the Number 1 **Operational Flight Shortfall** of the Aircraft *(List)*?

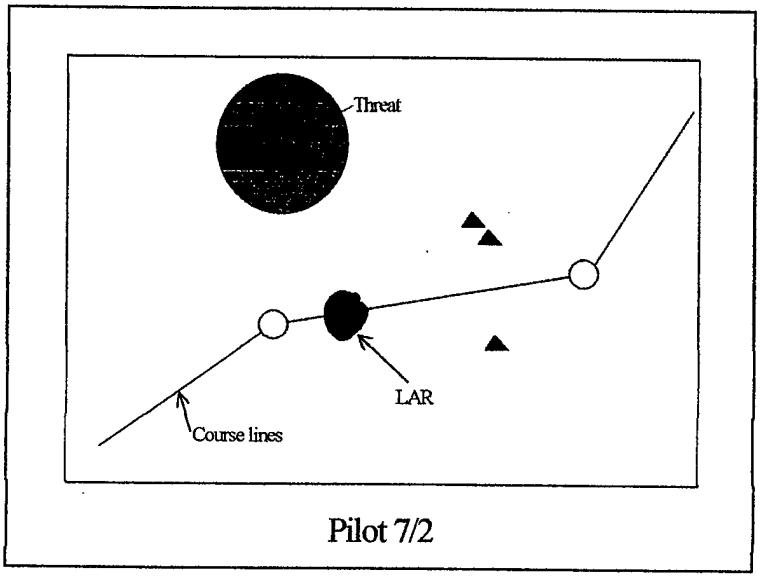
- Cockpit displays and computing power. With better displays and computers (color MFDs) the capabilities to get moving map, see displays at other station, etc. will greatly enhance non-verbal comm and SA.
- Real time target information/threat information
- To be able to data link and share information with other package players. Rather that piecemeal and Band-Aid fix the cockpit problems, the follow-on package should completely re-vamp the cockpit avionics. Especially if the B-1 will be around until 2030 as is projected
- Spare parts! Being able to load flight plan and CDC flight plan from the seam DTUC rather than two separate DTUCs.
- Moving map,
- NVG lighting,
- LAR presentation
- *JSOW, JASM priority
- Outdated computers
- New cockpit up front
- Moving map.
- Non-integrated SA - i.e. continue to have to use interphone for everything
- IFF – capability to identify friend or foe in an allied environment that includes Russian and French aircraft. This would assist in avoiding only enemy aircraft
- Altitude limitation - low 30s is still accessible to many threats. Flying above FL400 would be great.
- NVG capability
- Computer processing time needs to be improved to 1999/2000 standards with more memory
- 4th AC generator for improved EMUX reliability
- Icing/WX/IMC flying
- Pilots (and WSOs) need a color video display depicting the LAR. Something like this (see drawing below). This would be good for SA, tell us how to get to the TGT, the LAR, and avoid threats. Of course update every few seconds at least. I hope this does not cause any WSO union legal action.
- Data link (see question 4). Digital Bull and BRAA should be in Block D. Participant also had drawing (see below)

- Engines limiting (fuel scheduling) our high altitude capability. The B-1 is the most expensive theater (minus the B-52) for dropping bombs. At out altitudes we require package protection and air refueling (in operation Allied Force.) B-52s flew 40,000+ MSL and didn't need package protection or air refueling.

- Data link
- Precision weapon targeting.



Pilot 7/1



Pilot 7/2

B. WSO Experience: (6 participants flew as DSO/OSO; 5 DSO only; 5 OSO only)

Current Qualified Aircraft: B-1B Number of Flying Hrs: Ave: 966.38
Range: 250 – 2250

B-1B DSO Hrs: Ave: 460.67 Range: 125-1125 A/C Block: B/C/D

B-1B OSO Hrs: Ave: 515.13 Range: 125-1250 A/C Block: B/C/D

Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____

Total Flying Hrs: Ave: 1853.63 Range: 531-3750

2. B-1B Simulator Time: Yes: 16 No: 0

Type Sim: WST, CPT, Integrated Number of Hrs: Ave: 115.67
Range: 30-200

Purpose: (e.g. Upgrade training for Block X): All blocks; Student training/ mission planning; Block C training; training; FTO; IQC/CT; Continuation/currency; Requirements

4. Have you had previous B-1B Block D, E and/or F experience? Yes: 5 No: 11

If yes, what aircraft/simulator(s)? 4 A/C; 1 sim Number of Hrs: Ave: 69.5
Range: 8-150

5. Have you had any AFMSS Training? Yes: 7 No: 9

6. Have you had any training on GMTI? Yes: 5 No: 11

7. Have you had any training on JDAM? Yes: 8 No: 8

7. Are you familiar with Launch Acceptability Regions (LARs)? Yes: 9 No: 7

8. a. Have you ever participated in any B-1B studies or flight tests? Yes: 6 No: 8

b. If yes, describe:
- AFMSS mission prep;
- Edwards AFB test support;
- FCF;

- MRT;
- DMV-II;
- Link 16;
- FOTD
- ALE50/55 Human Factors,
- Workload and SA in Link 16,
- ALE-50 flights at Eglin

DSO Section

1. Rate the acceptability of the modified **ASQ-184 RWR Controls & Displays** *(Circle)*:

Average Rating: 5.27 (Highest score – 7; lowest 1)

a. Totally Acceptable	1
b. Very Acceptable	2
c. Somewhat Acceptable	7
d. Borderline	1
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Interference of trunk line with cardinal directions and TWF box
- Compass Rose and course lines interfere with TWF box
- Very good BRA and Bull info; nice if you can hook and emitter of the TSF and the cursor would track on the threat (this would allow you to track a threat and get a continuous BRA and Bull update for that threat.)
- More interactive capability is necessary
- No frequency readout on TSF or PF display
- WSOs always need to be able to change techniques
- Need NEAJAM! Need active selection of other techniques
- TSF super - good having track lines, however highlighting the portion we are sequenced to would be better. Great digital bullseye/BRAA
- The displays represented a very accurate "DF" capability - it might differ in the actual jet.

2. Rate the acceptability of the **CDU Controls & Displays for RF Countermeasures** (i.e., Towed Decoy & Low Band Jammer) *(Circle)*:

Average Rating: 5.73 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	8
c. Somewhat Acceptable	3
d. Borderline	0
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Not intuitive on activating/deactivating low band jammer
- Unsure how to activate low-band jammer. Towed decoy worked very well.
- On [AA] put a column showing if jamming is occurring and what the technique is on a threat
- DSO needs the ability to deploy countermeasures at will. System jammed threats at too great a distance. Such practice would only highlight the aircraft
- Better actual presentation when it is jamming vs. pending

3. Rate the acceptability of the **ALR-56M** *(Circle)*:

Average Rating: 5.64 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	8
c. Somewhat Acceptable	2
d. Borderline	1
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Good (retains a lot of the old ALQ-161 display). Needs to have more interaction with the DSO (i.e. if a threat comes up out of it's lethal range, the it should not automatically jam. The DSO should have the option to inhibit jamming if necessary).
- DSO needs to be able to select and deselect appropriate jamming techniques
- Looks good in the sim
- More stable than ALQ-161 system (maybe sim-ism)
- Really need audio on all capabilities.
- If it actually works as predicted then it is all good.

4. Rate the acceptability of the **Inter-Crew Coordination** *(Circle)*:

Average Rating: 5.64 (Highest score – 7; lowest 1)

a. Totally Acceptable	1
b. Very Acceptable	5
c. Somewhat Acceptable	5
d. Borderline	0
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Experienced crew able to detect most discrepancies. More prebrief info on weapons loadout would end cockpit discussions.
- More info needed to brief the sim before getting in the box (i.e. weapons load, targets, etc.)
- The BRA/Digital Bullseye enhanced crew coordination. These functions are essential to the mission
- Kind of N/A
- Pilots need more SA cues - LAR TTG to release on VSD similar to Block D currently

5. Rate the acceptability of **Communications** *(Circle one)*:

Average Rating: 5.30 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	5
c. Somewhat Acceptable	4
d. Borderline	0
e. Somewhat Unacceptable	1
f. Very Unacceptable	0
g. Totally Unacceptable	0
	1 no response

Comments:

- No problems
- Use of hot mic adds confusion
- N/A
- No change
- More comm due to pilots not having LAR TTG on VSD

6. Rate the acceptability of the EW **MFD Formats** *(Circle one)*:

Average Rating: 5.55 (Highest score – 7; lowest 1)

a. Totally Acceptable	1
b. Very Acceptable	4
c. Somewhat Acceptable	6
d. Borderline	0
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- See comment on item 1
- See comment for Item 1
- Again, change [AA] page to reflect what type of jamming is being used against a threat. Good use of being able to load three different Bulls.
- The type of jamming being used needs to be displayed on the [AA] page.
- Limited time with format. Could not back-up RDU on MFD
- See #1
- Can we get color screens to offer ability to reproduce ellipse/LARs

7. Rate the acceptability of the **CDU & ASQ-184 Combination** *(Circle one)*:

Average Rating: 5.27 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	5
c. Somewhat Acceptable	4
d. Borderline	2
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Overall, an improvement over current system. Need threat audio to detect mode changes for proper crew reaction
- Good options built-in and easily accessible through menu formats.
- The entire system needs to be more interactive
- Same as before
- Since these systems are virtually independent their "combination" is not really applicable
- ILST is good - may need a BWI read-out underneath current track read out

8. Rate the acceptability of the **RFS/ECM Panel** *(Circle)*:

Average Rating: 5.30 (Highest score – 7; lowest 1)

a. Totally Acceptable	1
b. Very Acceptable	2
c. Somewhat Acceptable	6
d. Borderline	1
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0
	1 no response

Comments:

- No capability by the DSO except ON/OFF. Need to be able to inhibit jamming by switching ARM/SAFE on transmitter
- Did not work well in the simulator. The system displayed no apparent function,
- Change inoperative button to something useful
- Need NEAJAM
- Not much to do - no change for keys that are used.
- Discuss more on how to enter Lethal vs. Norm mode - not all full-up system represented.

9. Rate the acceptability of the overall **Threat Situational Awareness** *(Circle)*:

Average Rating: 5.73 (Highest score – 7; lowest 1)

a. Totally Acceptable	3
b. Very Acceptable	3
c. Somewhat Acceptable	4
d. Borderline	1
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- See comment for Item 7
- Great! Only thing was to be able for the cursor to track a threat so you can get continuous Bull and BRA information for the threat.
- DSO needs to be able to control the type of jamming being used.
- The Digital Bull and BRAA with moving NSEW (Compass Rose?) is a must! Huge increase in SA. Provides accurate and timely location of threats enabling that information to be passed to all aircraft in strike package and AWACS for total package SA
- Could add status i.e. search/track and range on TSF displays
- New TSF format with cardinal directions is great! ALR56 will take getting used to. I felt less SA in threat environment as for knowing if threats were "covered" and with what. (Yes, I don't trust IDECM to do its thing without adult supervision.)
- If the system works as depicted it's acceptable - the "threat" ping is somewhat confusing - need to have separate tones.

10. Rank Order *(Low = 1)* the following in terms of **Operational Usefulness:** For each write in what **Operation Shortfall/Capability** it addresses:

	R.O.	OPS Issue
Data Link	_____	_____

- Improve situational awareness (SA)
- SA
- Allows the crew to know the battle picture
- See other comments
- Gives targeting flexibility
- Package integration
- Threat data, fighter picture
- Very useful! Want it!
- comm / replan option

Color Head Down Displays _____ _____

- See other comments
- Better SA displays
- SA

Moving Map _____ _____

- Improve SA
- Navigation / SA
- More for OSO use would greatly increase OSO's SA on LAR
- See other comments
- Need real-time depiction of LAR
- Need this ASAP (with visual LARs and threat overlays)
- Increased SA
- SA / replan option

Off-Board Mission Planning _____ _____

- AFMSS needs significant improvement
- Decrease the mission planning time
- See other comments
- Planning mission

On-Board Mission Planning _____ _____

- Capability to calculate new LAR in-flight
- See other comments
- Re-targeting, change of plans

Compass Rose _____ _____

- Simple improvement that significantly improves SA
- SA
- Increases DSO SA
- See other comments
- Adds SA
- Increase SA, survivability

- Better SA, increase awareness of threat position
- SA

Digital Bullseye

- SA / Communication
- Builds OSO's SA on threat picture
- See other comments
- Adds SA
- Increase SA, package integration, and survivability!
- Better SA, better comms with AWACS and Blue Air
- SA

Other

- FLIR
- RTIC (Real-time Information in Cockpit - multiple sources)

11. After the B-1B Block D, E, and F Upgrades are completed, what will be the Number 1 **Operational Defensive Shortfall** of the Aircraft *(List)*?

- Relay of real-time threat / target change info
- Data link
- Trying to calculate a new LAR for contingencies in the air (moving map for OSO with updated LAR information.)
- Inability to easily reselect JDAMs to different targets while airborne.
- The OSO is very busy cycling between formats (i.e. LAR location, SMS page, CNAV summary) during the bomb run. Combine more information on the same page
- The DSO will not be able to jam any threats. Should the system make a mistake, there is no way to correct it. The only apparent way to stop the system is to turn it off, thus leaving no ECM available. The DSO should have the ability to jam individual threats. The BRA/Digital bullseye information is a must for modern warfare. Other systems should be sacrificed to add this capability to the B-1B. There is no excuse for not having a digital bullseye.
- Inability to re-ID threat
- Inability to reprogram jam technique
- Operator inputs
- Let's see how D,E and F, really work when fielded
- Need repeater for pilot station
- RTIC (if not installed)
- Lack of self-protection; air-to-air, air-to-ground (HARM) ordinance
- Need multiple ECM techniques in combination
- 1122 taken out (need)
- NEAJAM taken out (need) - Put back in.
- Kinematic flares / multi-color flares
- Higher frequency coverage for 161/184
- RWR display in front cockpit
- Use ATRJ instead of ASPJ for jamming processor
- Better inlets; more speed
- Bigger windows for DSO/OSO
- More Gs
- For defensive system I think the biggest shortfall will be data link capability.
- Need BULL indications
- LAR SA indications to pilots

OSO Section

1. Rate the acceptability of the **WCMD display formats** *(Circle)*:

Average Rating: 3.88 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	0
c. Somewhat Acceptable	2
d. Borderline	4
e. Somewhat Unacceptable	1
f. Very Unacceptable	1
g. Totally Unacceptable	0
	3 no response

Comments:

- Confusion on procedures to effect weapons release
- N/A (didn't really see it)
- Once all parameters are met except reaching launch point bomb light should illuminate inbound target from IP (i.e. switches set, aircraft heading within tolerances
- N/A for mission 1
- Need distance to LAR! Too many page changes. Information overload; after some practice, all need information could be reduced or simplified and placed on a "C" navigation summary page!
- Did not like the word "NONE" referring to weapons not allocated to target, would rather see the weapon's name there such as CBU-103, JDAM, etc. Let's OSO know that there is a weapon at that station verses stating none. The "X" is OK for a released weapon.
- Still needs some kind of steering to LAR

2. Rate the acceptability of the **JDAM display formats** *(Circle)*:

Average Rating: 3.90 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	0
c. Somewhat Acceptable	4
d. Borderline	2
e. Somewhat Unacceptable	3
f. Very Unacceptable	1
g. Totally Unacceptable	0
	1 no response

Comments:

- LAR display did not seem to show correct information. IR/IZ displayed immediately on sequence to target, but weapons did not release.
- The formats seem ok, but they are located in too many different locations. For example, maybe combine more information on LAR STAT page
- Weapons bays need to be labeled on [D] page.
- Current TTG to LAR on E page should be displayed well prior to IP. Range to acceptable launch point should be displayed. Easy target allocation should be done by selecting location and station - "enter"
- TTG to release should be displayed on the LAR page for each LAR
- Takes a while to step through each weapons allocation to get to the one you want. Would be nice to be able to page through instead of just stepping through each individual weapon allocation to get where you want
- Blocked status of JDAMs should be reflected on E-format not just on D-format

3. Rate the acceptability of the **ILST** *(Circle)*:

Average Rating: 6.91 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	10
c. Somewhat Acceptable	1
d. Borderline	0
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Significantly improves SA, ensure ease of switching radar modes (ILST, GMTI, real beam, rendezvous.) A few display indicators caused confusion (e.g. tanker offset symbology.
- Tanker offset information? What does it really mean?
- More usefulness in detecting AI threats than a Tanker rendezvous
- The display needs to be less cluttered. A current target often overlaps with a new target. There needs to be a way to separate the two.
- Optimally - track more than one target (contact). Move radar return numeric data away from actual return
- If using for tanker rendezvous, doesn't show beacon information for the tanker requiring crew coordination to confirm correct tracker.
- Nice system! But MAKE SURE the display of date is identical to all other aircraft air-to-air radars. The is an AF standard for data display
- Too much written information on actual screen! Need center azimuth line.
- Good SA to tanker
- Real important to put "Bullseye" info on this display

4. Rate the acceptability of the **LAR displays and targeting information** *(Circle one)*:

Average Rating: 3.27 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	0
c. Somewhat Acceptable	1
d. Borderline	5
e. Somewhat Unacceptable	2
f. Very Unacceptable	2
g. Totally Unacceptable	1
	1 no response

Comments:

- Displayed WCMD LAR fine for 1st target, unable to display LAR for 2nd target complex
- See comments for Item 2.
- Good use on putting the ALR location on [EB], but put more information on it. Good also to put more target information on the [EB] besides the bars (i.e. TTG to LAR).
- The LAR display needs to be re-vamped. The [EB] page is nearly useless. There is no way to view the distance between the individual LARs. There needs to be a constant running bearing to the LAR, regardless of whether the plane is sequenced to the target or not.
- OSO needs range to launch point (LAR) suggestion: Have top bar of LAR bar not appear until aircraft is within all parameters to launch JDAM
- When dropping CBUs countdown to weapons release did not work cycled between 59:59 - 0:00 until just released weapon without warning.
- Not enough SA on LAR location
- Need continuous RANGE and TIME information! Need center azimuth line! Less information!
- Pilots do not have SA on LAR. OSO had to notify pilots... due to tasks pilots need information displayed on LAD on VSD.
- No LAR steering, plus no way of knowing range between LARs

5. Were you able to use the LAR Display to **steer** to the upcoming weapons LAR(s)?

Yes 8 No 3 Comments:

- Not required based on aircraft heading but could've been accomplished. That said, the LAR bar depiction does not give the magnitude of the turn required to meet LAR parameters (i.e., # of degrees to turn to meet LAR criteria)
- Not effective because not familiar with system
- The LAR display provided virtually no help in getting to the LAR.
- During the sim the crew steered toward LAR, but did not get a release when within the LAR
- Would be better to have actual bearing in degrees instead of just an ⟶
- Would be nice to know where LAR centers are (for better steering information and also maximum stand off)
- Yeah, but really did not need it. Good mission planning/study and a good chart would provide same information.
- However, the biggest problem is having to switch Format Pages too often during bombing.

6. Were you able to follow the **sequence of weapons releases** using the LAR Display?

Yes 4 No 6 Comments: 1 Yes/No

- Only first three weapons were displayed for first target complex. Only 1 weapon displayed for 3rd target complex
- Lack of training on Blocks made it difficult, but with time and practice, should be ok
- very confusing when dropping CBUs; ok with JDAM
- I understand the basics, but need training on the new information.
- Too busy

7. Rate the acceptability of the **Inter-Crew Coordination** *(Circle one*:

Average Rating: 5.09 (Highest score – 7; lowest 1)

a. Totally Acceptable	1
b. Very Acceptable	1
c. Somewhat Acceptable	7
d. Borderline	2
e. Somewhat Unacceptable	0
f. Very Unacceptable	0
g. Totally Unacceptable	0

Comments:

- Pilots seem to have no information on the LAR
- Weapons status needs to be better coordinated between OSO and the pilots. The door configurations differed between the forward and aft station.
- CDU and INS NAV will an issue to work through
- NUC circuitry is another switch error nightmare. 3 switches to get the bombs off
- WSOs don't know what the CNMS is providing to the pilots
- Pilots need better cueing on LAR in front station as well as RAW threat picture with ALR-56M radar scope.
- Better controls and displays up-front would minimize this.

8. Rate the acceptability of the **Communication & Coordination with the Outside World** *(Circle one)*:

Average Rating: 4.90 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	2
c. Somewhat Acceptable	6
d. Borderline	1
e. Somewhat Unacceptable	1
f. Very Unacceptable	0
g. Totally Unacceptable	0
	1 no response

Comments:

- No "background" communications which would detract from SA or help.
- Need data link.
- The radios are not enough to properly communicate. A data link is essential
- No hangers(??) in aft station
- N/A

9. Rate the acceptability of the **Target Situational Awareness** *(Circle)*:

Average Rating: 4.09 (Highest score – 7; lowest 1)

a. Totally Acceptable	0
b. Very Acceptable	1
c. Somewhat Acceptable	4
d. Borderline	2
e. Somewhat Unacceptable	3
f. Very Unacceptable	1
g. Totally Unacceptable	0

Comments:

- LAR did not help awareness of where the release should occur.
- Once a target has been hit, have the current target information come up on the [FCC] first and also on the [E] page. For example, had to use my arrow keys to see target 10 information after we passed over target 8.
- Need targets depicted on chart, without range information to acceptable launch point is imperative.
- Need to be able to keep TTG to release up at all time during IP to target run.
- need to get familiar with LARs
- Bombs start coming off sooner than expected. Lack of SA
- New systems are not responsible for this
- Displays for JDAM and WCMD are too busy. Also OSO had to change to different formats too often.
- Our mission planning was unrealistic - better prior mission planning would eliminate some of this confusion

10. Rank Order (*Low = 1*) the following in terms of **Operational Usefulness:** For each write in what **Operation Shortfall/Capability** it addresses:

	R.O.	OPS Issue
Data Link	_____	_____
• SA		
• allows the crew to know the battle picture		
• mission essential		
• improvement of time management		
• Target changes /CAS/AI		
Color Head Down Displays	_____	_____
• Important for information sorting		
• More efficient cockpit management		
Moving Map	_____	_____
• More for OSO use would greatly increase OSO's SA on LAR		
• Essential for LAR usage		
• (Must have); most important for SA		
• Huge SA builder		
• SA greatly needed		
• Don't ask-absurd that a $280 million airplane doesn't have it!!		
Off-Board Mission Planning	_____	_____
• Decrease the mission planning time		
• Need the PC PGM solution ASAP (kill MPS)		
• AFMSS - giant paperweight		
On-Board Mission Planning	_____	_____
• Capability to calculate new LAR in-flight		
• Should be last consideration		
• With data link capability re-targeting will be routine and this is needed		
• On global power mission, a must		
• I'm a WSO I can do it now		
Global Air Traffic Management (GATM)	_____	_____
• Increases DSO SA		
• ?		
Digital Bullseye	_____	_____
• Builds OSO's SA on threat picture		
• Virtually impossible to function in modern aircraft without it.		
• A must for package integration and survivability		
• Too easy, make it happen		
Other _____	_____	_____
• FLIR		

- RTIC; threats
- Need new MFDs and graphics generator. Need new color MFDs and true graphics generators to allow displayed information on weapons to be better depicted.

11. After the B-1B Block D, E, and F Upgrades are completed, what will be the Number 1 **Operational Offensive Shortfall** of the Aircraft *(List)*?

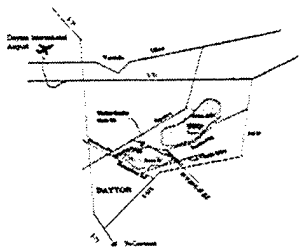
- See previous comments in OSO section
- Data link
- Trying to calculate a new LAR for contingencies in the air (moving map for OSO with updated LAR information.
- Inability to easily reselect JDAMs to different targets while airborne.
- The OSO is very busy cycling between formats (i.e. LAR location, SMS page, CNAV summary) during the bomb run. Combine more information on the same page
- In order to properly utilize JDAM, JCEM and JSOW a moving map display must be used. Proper implementation of these systems will not occur until a moving map display is integrated into the airframe. The aft avionics should be stripped and replaced. The lack of computing power is unacceptable. The current upgrades are good, but they cannot make up for the necessary hardware changes. Most of the displays and computers need to be replaced. A FLIR would add a lot to the aircraft.
- ACUC future limitations for follow-on weapons and upgrades. "Avionics computers need to be Y2K technology."
- Need to wait and see.
- Beyond line-of-sight data link
- Two-way communications, Information passing
- 4th generator
- Computers
- RWR repeater display for pilots
- RTIC
- Flare button for pilots
- Replacement parts (parts train)
- Need the ability to precision guide weapons via data link, TV-guided weapons and laser-guided systems incorporated on the B-1
- Engine performance - need new engines.
- - Better controls and display for both front and back station to help our SA

APPENDIX 3 – GENERAL ORIENTATION BRIEFING

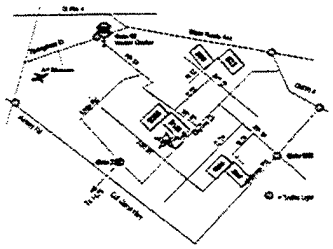
B-1B BASELINE STUDY ORIENTATION

Mr. William G. Kalman
DSN 785-4258
Ms. Jane Kline
DSN 785-7852
Maj. Scott Provost
DSN 785-8280
ASC/ENFC-CSEF

Airport to WPAFB



Area B



Baseline Study Objective

- Examine Effects of Blocks D, E, & F on Crew Workload, Situational Awareness, & Coordination
- Establish Measurable Standards to Judge Future Block Upgrades

Baseline Study Particulars

- 8 Full B-1B Crews will participate
- B-1B ERS Baseline Study Configuration
  - Pilot/Copilot = Block D
  - DSO = Block F
  - OSO = Block E
- Data Will be Recorded & Analyzed
  - Subjective Workload Assessment Technique (SWAT)
  - Situational Awareness
  - Questionnaires
  - Video Tape
- 3 Practice Missions & 2 Data Missions
- Report will be issued to ASC/YDE

SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE (SWAT)

SWAT

- Workload is Defined as:
  - Time Load
  - Mental Effort Load
  - Psychological Stress Load

Time Load

- Total Amount of Time available to accomplish a task as well as overlap of tasks or parts of tasks

1. Often have spare time (Low)
2. Occasionally have spare time (Medium)
3. Almost never have spare time (High)

Mental Effort Load

- Amount of Attention or Concentration that is required to perform a task

1. Very little conscious mental effort or concentration required (Low)
2. Moderate mental effort of concentration required (Medium)
3. Extensive mental effort and concentration are necessary (High)

Psychological Stress Load

- The Presence of Confusion, Frustration, and/or Anxiety associated with task performance

1. Little confusion, risk, frustration, or anxiety exists and can be easily accommodated (Low)
2. Moderate stress due to confusion,frustration, or anxiety noticeably adds to workload (Medium)
3. High to very intense stress due to confusion, frustration, or anxiety (High)

SWAT
Card Sorting

- Done Once Prior to any Missions
- Arrange 27 Cards from Low Workload to High
- Each Card has 3 Descriptors:
  - Time Load
  - Mental Effort Load
  - Psychological Stress Load
- Each with Assigned Level
  - 1 (Low), 2 (Medium) or 3 (High)
- Card Sort is for SWAT Familiarization
- Card Sort Aids SWAT Analysis

SWAT
Event Scoring

- Asked for during 4 Mission "Freezes"
- Each Crew Member will Assign either a 1, 2, or 3 to each of the 3 Categories:
  - Time Load
  - Mental Effort Load
  - Psychological Stress Load
- Category Order will Always be the Same
- *(SA will also be collected during same "freeze" just after SWAT)*

Situation Awareness (SA)

Situational Awareness

- Situational Awareness (SA) is crew member's internal model of the world around him/her at any point in time
  - Level 1: Perception of Elements in Current Situation
    (e.g., Red Light Appears)
  - Level 2: Comprehension of Current Situation
    (e.g., Red Light means Engine #4 is on Fire)
  - Level 3: Projection of Future Status
    (e.g., Pushing Fire Extinguisher Button will put out Fire)

Situational Awareness

- Crew flies mission
- 4 Mission "Freezes"
- Crew is individually questioned about SA
  - Own ship and Environment
  - SA Questions Selected Randomly from List
  - *(SWAT will also be collected during same "freeze" just before SA)*
- Answers are compared to Actual Situation
- SA score is determined (SA/No SA)

Situational Awareness
Pilot & Copilot

- Own Ship
  - Heading (+/-3°)
  - Altitude (+/-300 ft.)
  - Radio Frequency (+/- 0.50)
- Environment
  - Threat Azimuth (+/- 5°)
  - Threat Type/Status (Zero)
  - Time to Waypoint/Target (+/- 10 seconds)
  - Bearing/Heading to Target/LAR Envelope (+/- 5°)

Situational Awareness - DSO

- Own Ship
  - ASQ-184 Mode (RMP AUTO, RMP SEMI, PREBRIEF, RMP MAN)
  - ALR-50 Status/Mode (Decoy Status, Left/Right Launcher, Transmitting, Auto/Man, Technique)
  - ALR-56M Mode (Lethal/Normal)
  - Low Band On-Board Jammer Status (Generating RF [Rays], Degraded Mode [Brackets])
- Environment
  - Threat Status ("New Guy" Flash, Priority Diamond for Float, Sequenced, and Select Audio, Flashing Launch Box, Jammed/Not Jammed Emitter [dim on Battle Management Page])
  - Threat Type (SAM, AAA, MIG)
  - Threat Priority (1, 2, or 3)
  - Threat ALR-56M Azimuth (AOA +/- 5°)
  - Threat ALR-56M Range (+/- 1 Nm)

Situational Awareness - OSO

- Own Ship
  - WCMD/JDAM (Type/Location, Status, Target SN, Key Status)
  - Hung Stores (Bay 1,2, 3, Inboard/Outboard)
  - Bearing/Range from A/C to Cursor (BRA)
  - ILST Status/Mode
  - Own Ship Location (Lat/Long [hours, minutes])
- Environment
  - Relative LAR Location (Heading, Right/Left Cross Track Range, JDAM Constrained ["in-zone"]/Unconstrained ["in-range"], WCMD SFW "in-zone"/"in-range")
  - Time to Waypoint/Target (+/- 10 seconds)
  - Targets (Tgts Enabled/All, Tgt SN, Type, Bearing, TTG, Range/Zone Status, Delivery Status [AVL/REQ])
  - New Target Location (Lat/Long [hours, minutes])

Time and Accuracy Measures

May Be Culled from Video Tape

Examples:

- Pilot/Copilot - Time to Recognize & Avoid Threat & any Errors
- Pilot/Copilot - Time to Enter new Radio Frequency & any Errors
- Pilot/Copilot - Time to Regain LAR & any Errors
- OSO - Time to Enter New Waypoint & any Errors
- OSO - Time to Resequence around Hung Stores & any Errors
- OSO - Time to Divert & any Errors
- DSO - Time to Deploy ALR-50 Towed Decoy & any Errors
- DSO - Time to Recognize Threat & any Errors

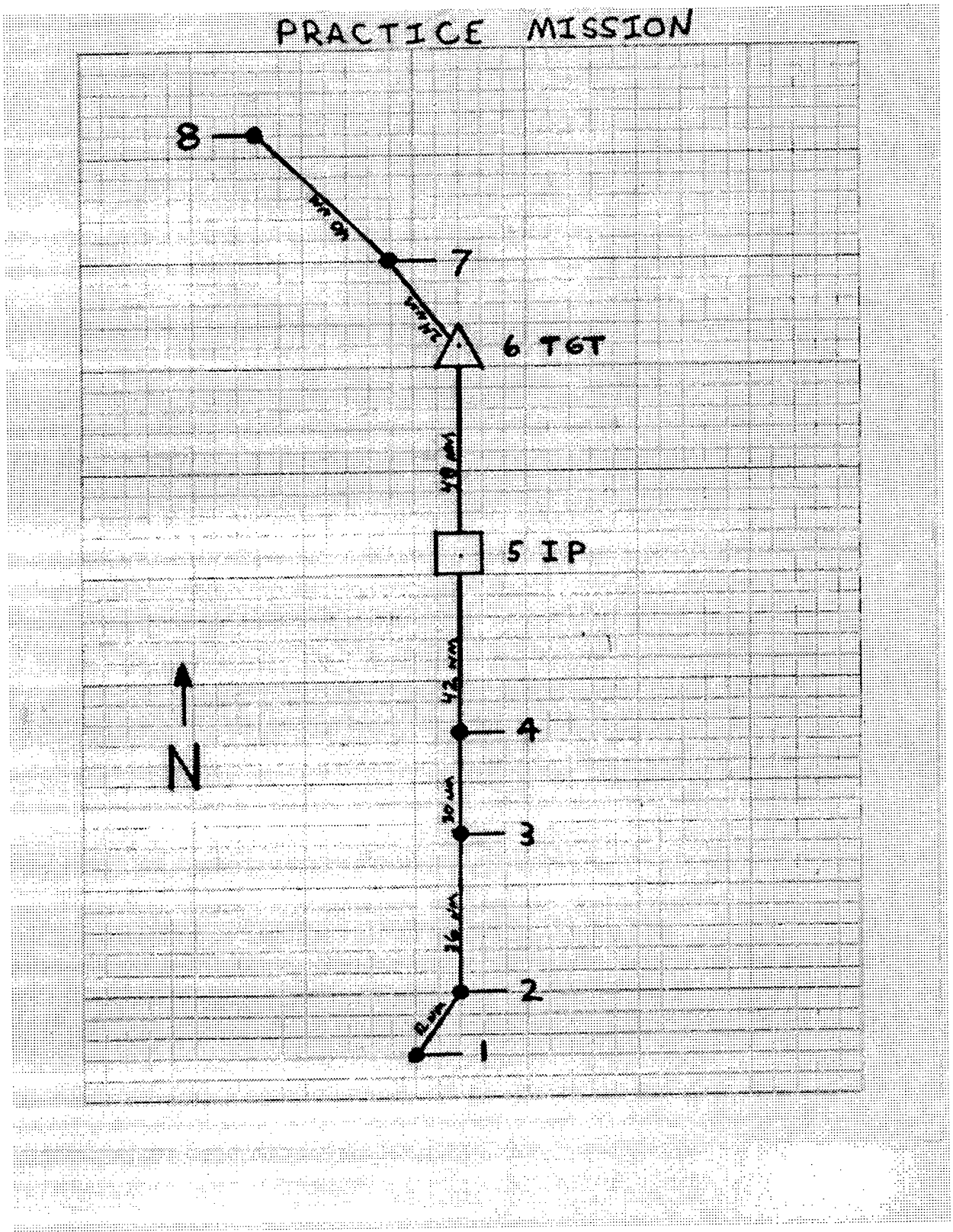
Questionnaires

- Personnel Information
- Experience
- Ratings
- Rank Ordering
- Comments

SWAT

Card Sorting

- 3 Factors each with 3 levels = 27 Possible Combinations
- 27 Cards
- Each Card has 3 Factors on it
- Arrange deck from Lowest Workload Card (bottom of deck) to Highest Workload Card (top of deck)
- No Wrong Answer
- Arrangement of Deck will be your Personalized Prioritization of Workload



APPENDIX 4 – PRACTICE MISSIONS DETAILS

D#	LATITIDE LONGITUDE	ETE ETA T/T
1	N34.20.00 W106.27.70	00+02+29 19:50:29 00:02:29
2	N34.40.00 W106.00.00	00+02+55 19:53:24 00:05:24
3	N35.00.00 W106.00.00	00+04+23 19:57:47 00:09:47
4	N35.50.00 W106.00.00	00+03+36 20:01:23 00:13:23
5 IP	N36.20.00 W106.00.00	00+05+03 20:06:24 00:18:24
6.8	N36.40.00 W106.00.00 TARGET GROUP	00+01+24 20:07:48 00:18:48
6.9	N37.00.00 W106.00.00	00+04+18 20:12:06 00:24:06
7.9	N37.40.00 W106.30.00	00+07+06 20:19:12 00:21:12
8.9	N37.07.00 W106.50.00	00+05+48 20:25:00 00:37:00

APPENDIX 5 – MISSION BRIEFING SLIDES

Missions

General Mission Brief

- B-1B ERS is like CPT not WST
- B-1B ERS Take-Off Procedure
  - A/C is parked on Ground
  - DSO "Unfreezes" Simulator
  - Advance Throttles
  - Parking Brake OFF
  - Taxi to Correct Heading
  - Use Normal Take-Off Procedure
- Try to Operate only Necessary Controls
- Auto-Pilot not Coupled to CMNS (FLT DIR Rotary Knob position "CNMS")

General Mission Brief

- **HIT YOUR ETAs**
- To Start/Unfreeze Mission, DSO presses Recorder ON/AUTO on IKB Pnl once Everybody is Ready (This starts simulator, ETA countdown, computers, etc.)
- Fly at about 24,000 MSL
- No Need for TAL Maneuver to Align JDAM/WCMD Inertial
- JDAM/1 = Mk 84, JDAM/3 = BLU-109
- Use Expanded Checklist, Section 2, for JDAM Info
- May try MAN Jettison or Reallocate Bombs if Hung Store

General Mission Brief

- B-1B ERS "Notes" are on Whiteboard
- Leave microphones on HOT MIC
- Use True Course Heading (No MAG VAR in Bomb/Nav & CNMS Readouts)
- On ILST, Tanker is Assigned 25,000 ft MSL
- Full CHAFF/FLARE Load
- TSF will have Compass Rose & Digital Bulls Eye

Threats

- SA-3 GOA
- SA-6 GAINFUL
- SA-8 GECKO
- DO NOT GO BELOW 15,000 MSL
  - ZSU-23-4 SHILKA
  - Possible SA-7s & SA-9s
- Threat Warning Tones Work (DSO make sure Emitter VOL control knob is @ MAX VOL on Inter-Comm Panel)

Practice Missions

- 3 Practice Missions
  1. ILST - KC-135 @ WP 3 w/Orbit Pattern 20 x 20 miles
  2. Threat near WP 5
  3. Hung JDAM, Threats
- Common Information
  - All 3 Routes are the Same
  - WPs 1-8
  - WP 1 is T/O Point
  - WP 5 = IP, WP 6 = TGT (Tank Ba HQ)
  - Fwd 8 JDAM/3 (Delay Fuse), Int 8 JDAM/1 (Contact Fuse), Aft 10 WCMD CBU-103 CEM (Proximity Fuse)
  - 26 Total Bombs

Data Missions

Mission 1 - UTTR Scenario

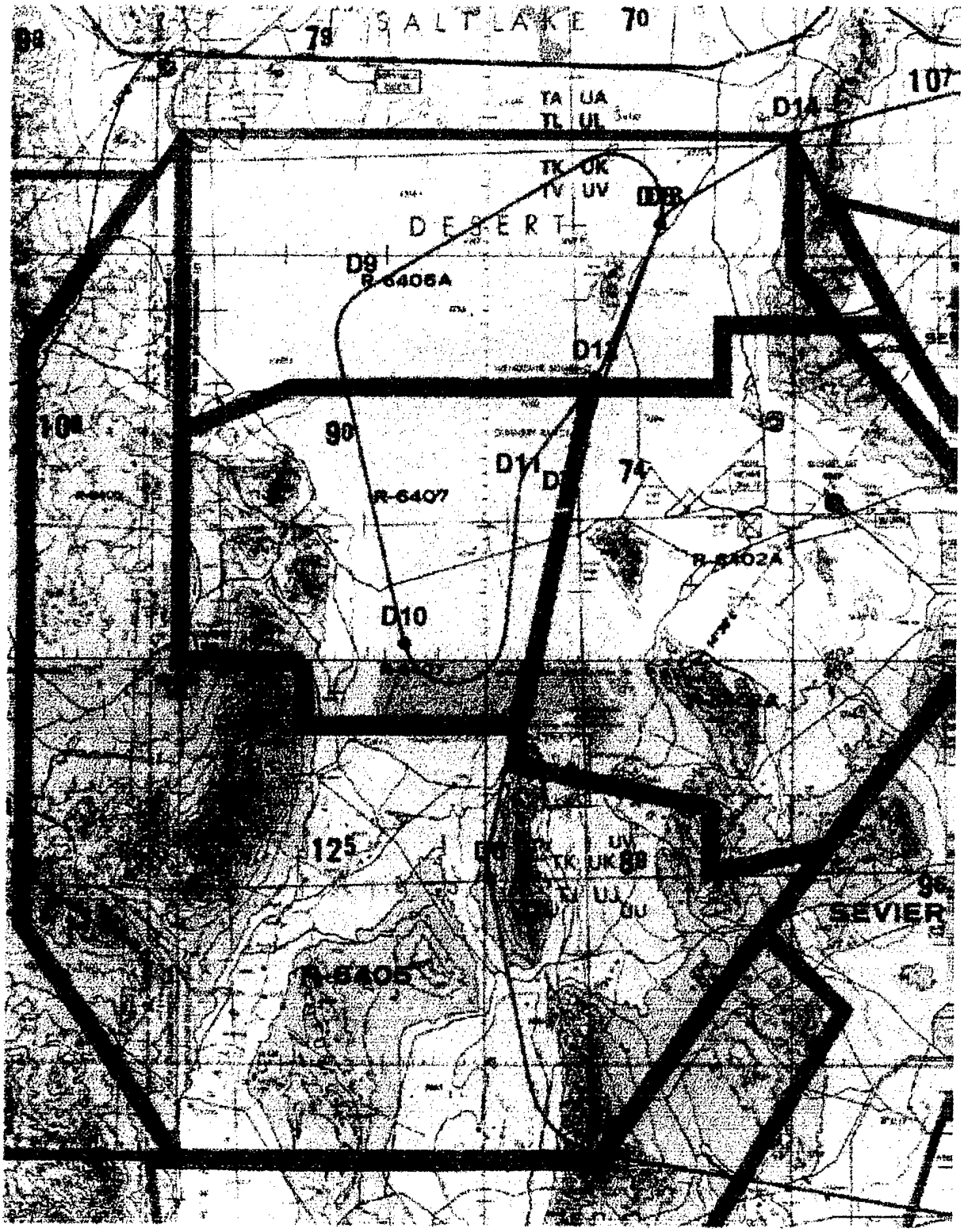
- **2 Types of JDAMs** (Fwd - 8 BLU-109s w/Delay Fuse, Int - 8 Mk 84s w/Contact Fuse, Aft - 8 BLU 109s w/Delay Fuse) (24 Total)
- **Possible Hung Store(s)** (Try to Use Appropriate Stores, BLU-109 on Hard, Mk 84 on Soft)
- **WPs 4 - 15, IPs = D7, D9, D11**
- **3 Target Groups** (D8 Command & Control Bunker, D10 Electrical Transformer Sub-Station, D12 Tunnel Complex)
- **Possible Threat Diversion between WP D9 & D10** (SA-6, Notch Range Envelope Clockwise to East)
- **Possible Diversion to Alternative Landing Field** (a. Pilot enter TACAN code into CDU, b. or enter new destination as a Way Point into flight plan using 3-letter ID, c. or LAT/LONG: OSO enter LAT/LONG into Nav Page)

Data Missions

Mission 2 - Powder River Scenario

- Tanker Orbit between WP D4 & D5 (ILST)
- Don't have TDS deployed during TNKR RNDVS (Tanker is A/C @ 25K ft MSL)
- WCMD CBU-103 CEM (10 Fwd Bay w/Proximity Fuse, 10 Int Bay w/Proximity Fuse, Aft Bay Empty) (20 Total)
- Red Circles on Map MAY be Threats
- WPs 2 - 13, IPs = D7, D9, D11
- 3 Target Groups (D8 Truck Convoy, D10 Troops in Open, D12 Truck Convoy)

APPENDIX 6 – DATA COLLECTION MISSIONS DETAILS



D # ACTION PT FIX BULLSEYE	CHNL WIND H/A	LATITUDE LONGITUDE ELEVATION	MH MC TC	ALTITUDE MACH DIST	TAS GS CAS	ETE ETA T/T	ATA G/W	F/F L/F F/R
14 .delay 313/643	270/050	N 40 38.985 W112 59.380 5135	042 045 059	24000M .69 0.0	420 462 296	00+18+10 19:29:36 02:16:21	277281	25000 7985 89233
15 TURN SALT LAKE CIT KSLC/R 313/638	115X 270/050 30	N 40 51.015 W111 58.915 4220	059 061 075	24000M .73 47.8	440 488 311	00+05+53 19:35:49 02:24:14	275616	17000 1665 87568
16 TURN ROCK SPRINGS KRKS/R 313/626	107X 270/050 30	N 41 35.413 W109 00.919 6780	054 057 071	24000M .69 143.0	420 467 296	00+18+08 19:53:57 02:42:22	270480	17000 5136 82432
17 TURN MEEDY MOUNTAI KDGY/R 314/610	109X 270/050 30	N 43 05.451 W106 16.621 5860	035 039 052	24000M .69 151.2	420 459 296	00+19+47 20:13:44 03:02:09	264874	17000 5606 76826
18 TURN NAV PT KRWR/R131029 316/610	270/050 30	N 44 27.500 W106 40.000 4873	328 335 347	24000M .69 84.9	420 405 296	00+12+33 20:26:17 03:14:42	261317	17000 3557 73269
19 TURN NAV PT KDGY/R018070 315/606	270/050 30	N 44 05.548 W105 27.718 4528	111 108 120	24000M .69 62.9	420 462 296	00+08+10 20:34:27 03:22:52	259004	17000 2313 70956
20 DELY FONDER ENTRY KMCA/T307059 316/599	270/050 30	N 44 51.960 W104 01.613 3350	034 039 050	24000M .69 78.2	420 457 296	00+10+16 20:44:43 03:33:08	256095	17000 2909 68047
20 .delay 316/592	270/050	N 44 51.960 W104 01.613 3350	035 039 050	24000M .69 0.0	420 457 296	00+45+00 21:29:43 04:18:08	226845	18000 29250 38797
21 TURN ELLSWORTH KMCA/T 315/596	025X 270/050	N 44 08.340 W103 04.105 3200	132 127 137	24000M .69 58.9	420 452 296	00+07+49 21:37:32 04:25:57	224630	17000 2215 36582

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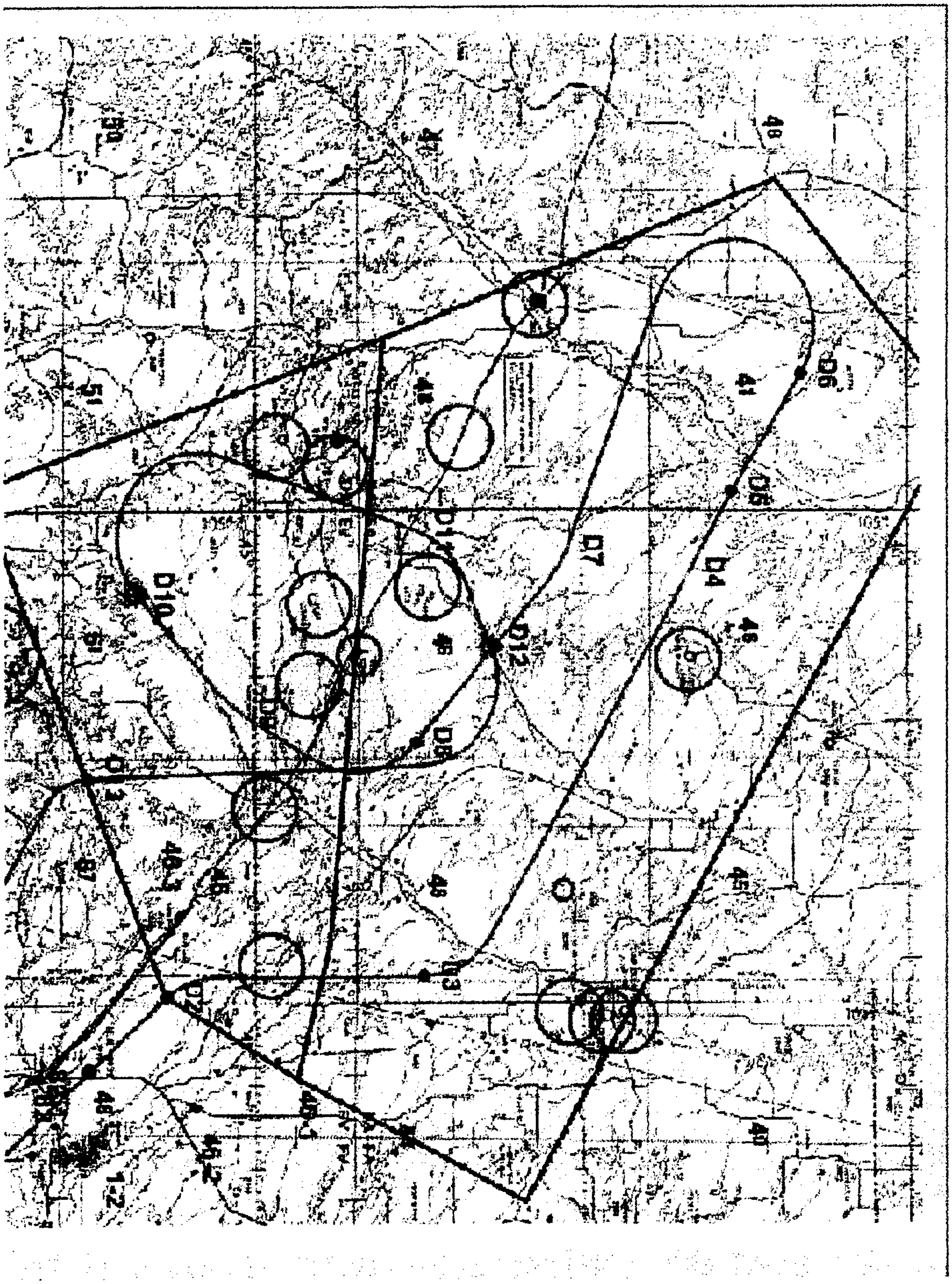
D6
D5
D4
D7
D10
D12
D8
D3

RouteName:A:\AJe_uttr.rte 9803011703 Re:AFMSS MDC v3.1.2 Route Report

CLEARANCE/FREQS	LAND:____ T/O:____ DUR:____	PID/SID ___/___ SAY MODULE #'S ___/___/___
Powder River	MSN:____ PACU:____ AFS:____ MWS:____	
	TOT DIST	TOT ETE	TOTAL FUEL
BULLSEYE: N 00 00.000 W000 00.000	415.7	00+50+29	17657

D #	ACTION PT FIX BULLSEYE	CMBL WIND B/A	LATITUDE LONGITUDE ELEVATION	MH MC TC	ALTITUDE MACH DIST	TAS GS CAS	ETE ETA T/T	ATA G/W	F/F L/F F/R
1 STTO	ELLSWORTH AFB KRCA/A 315/595		N 44 08.700 W103 06.217 3278	350 350 360	3278M 0.0		00+00+00 20:36:28 00:00:00	293059	 17000 103000
2 TURN	PWDR ENTRY KRCA/T307059 316/599	025X	N 44 52.043 W104 01.063 3347	308 308 318	6400M .65 58.4	420 420 386	00+08+32 20:45:00 00:08:32	292402	0 657 102343
3 TURN	 316/599	 30	N 45 15.612 W104 03.440 3301	345 345 356	6400M .85 23.6	550 550 506	00+02+35 20:47:35 00:11:07	292402	0 0 102343
4 IP	 317/602	 30T	N 45 40.080 W104 52.782 3189	290 290 301	6400M .83 43.2	540 540 498	00+04+48 20:52:23 00:15:55	292402	0 0 102343
5 TURN	LP 317/603	 30	N 45 44.058 W105 02.617 3002	289 289 300	6400M .83 8.0	540 540 498	00+00+53 20:53:16 00:16:48	292402	0 0 102343
6 TURN	 317/603	 30	N 45 50.393 W105 16.737 3150	291 291 303	6400M .83 11.7	540 540 498	00+01+18 20:54:34 00:18:06	292402	0 0 102343
7 IP	AR 316/602	 30T	N 45 28.825 W104 55.375 3170	100 100 111	6400M .83 46.6	540 540 498	00+05+11 20:59:45 00:23:17	292402	0 0 102343
8 TURN	 316/601	 30	N 45 14.938 W104 31.925 3563	118 118 130	6400M .83 22.7	540 540 498	00+02+31 21:02:16 00:25:48	292402	0 0 102343
9 IP	 316/601	 30	N 44 58.832 W104 33.538 3747	200 200 212	6400M .83 18.2	540 540 498	00+02+02 21:04:18 00:27:50	292402	0 0 102343
10 TGT	 316/602	 30	N 44 49.258 W104 50.277 3747	218 218 229	6400M .83 14.2	540 540 498	00+01+35 21:05:53 00:29:25	292402	0 0 102343
11 IP	 316/602	 30	N 45 15.148 W104 57.727 3646	009 009 020	6400M .83 38.4	540 540 498	00+04+16 21:10:09 00:33:41	292402	0 0 102343
12 TGT	BLF MM FED C1 .FED 10/D 316/601	 30	N 45 21.963 W104 43.759 3506	055 055 066	6400M .83 12.4	540 540 498	00+01+22 21:11:31 00:35:03	292402	0 0 102343
13 TURN	PWDR EXIT KRCA/T291069 316/601	025X 30	N 44 44.787 W104 27.757 3974	167 167 178	6400M .83 43.1	540 540 498	00+05+00 21:16:31 00:40:03	292402	0 0 102343
14 TURN	ELLSWORTH KRCA/T 315/596	025X	N 44 08.340 W103 06.105 3200	109 109 120	6400M .65 69.5	420 420 386	00+09+55 21:26:26 00:49:58	292402	0 0 102343

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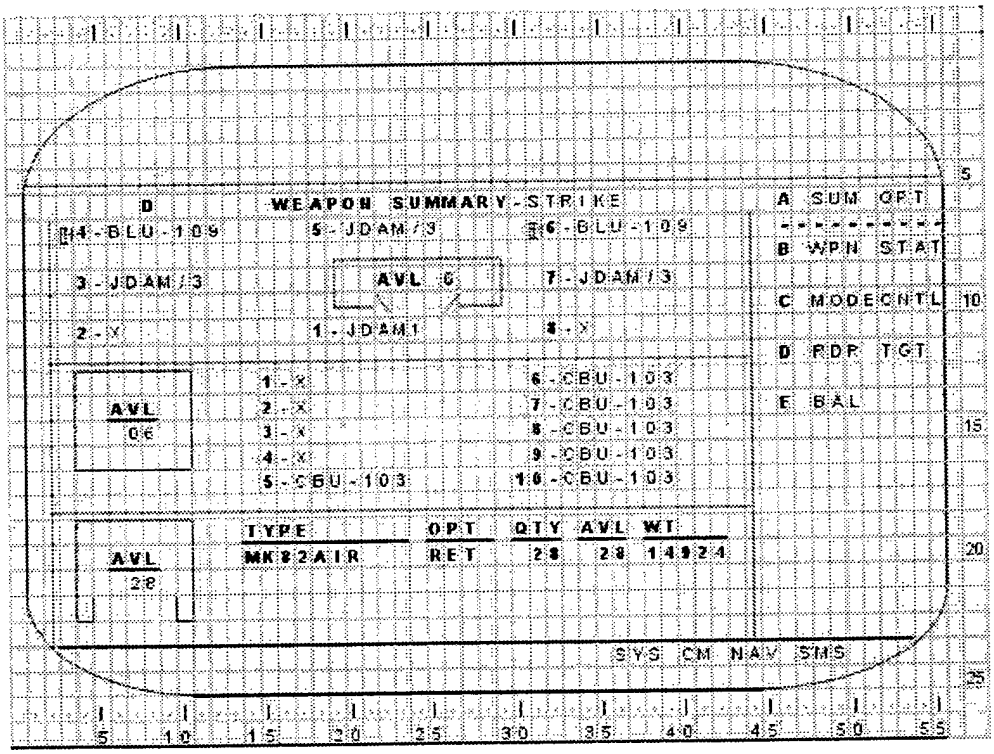
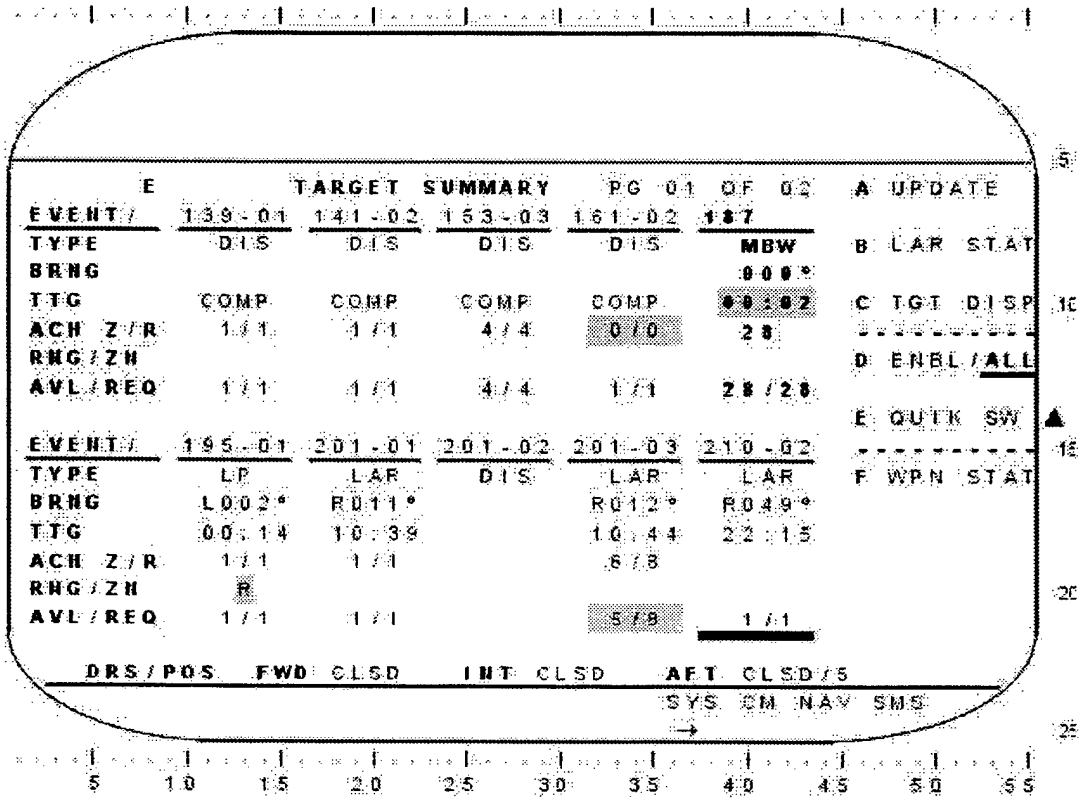
APPENDIX 7 – D, E, AND EB PAGES

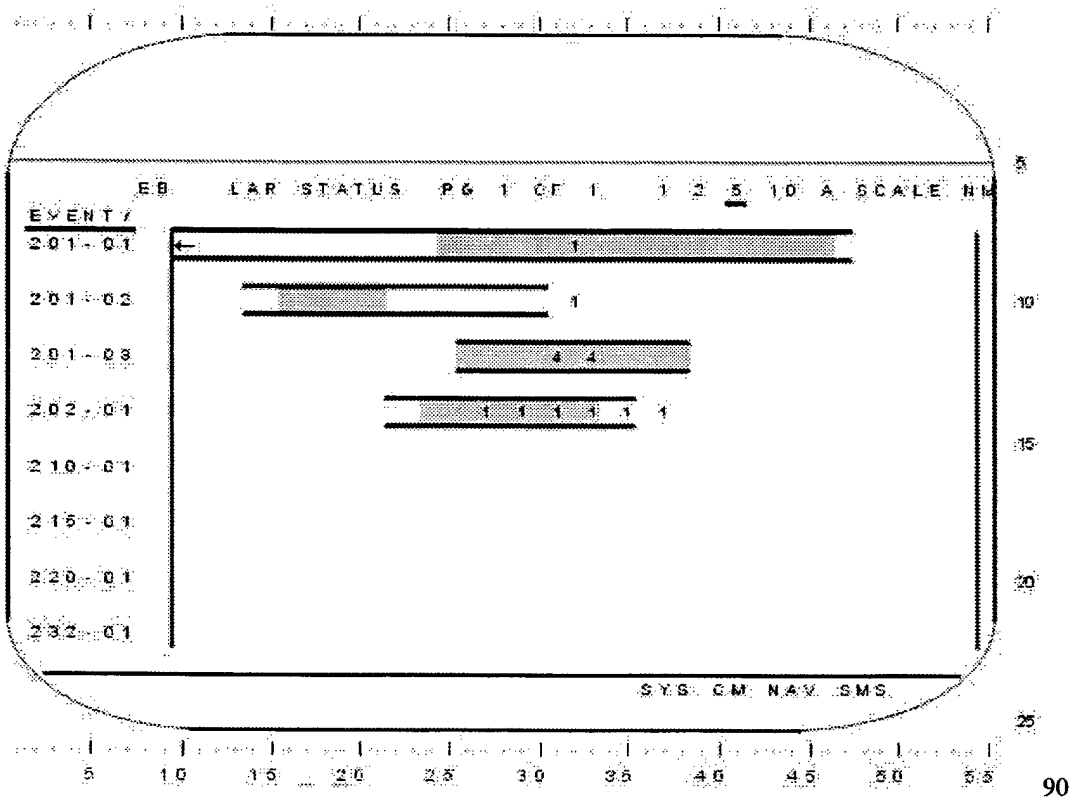
From Boeing MMI Document, 21 May, 1999

D PAGE



E AND EB PAGES





APPENDIX 8 – INDICES OF CENTRAL TENDENCY FOR SWAT

TABLE 1. INDICES OF CENTRAL TENDENCY AND DISPERSION FOR SWAT –CREW

		MSN									
		1					2				
		FRZPT					FRZPT				
		1	2	3	4	Total	1	2	3	4	Total
SWAT	Mean	13.95	19.71	30.65	31.03	23.97	8.03	11.80	30.56	25.74	19.03
	Median	.00	10.70	38.50	32.88	21.90	.00	5.35	29.93	27.25	14.30
	Mode	.00	.00	38.50	.00	.00	.00	.00	.00	.00	.00
	Std Deviation	19.63	25.41	18.46	28.15	24.07	12.93	15.00	23.51	22.80	21.12
	Range	63.75	100.00	63.75	100.00	100.00	49.15	49.15	70.40	70.40	70.40
	Minimum	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	Maximum	63.75	100.00	63.75	100.00	100.00	49.15	49.15	70.40	70.40	70.40

TABLE 2. INDICES OF CENTRAL TENDENCY AND DISPERSION FOR SWAT –PILOTS (FLIGHT CREW)

		MSN									
		1					2				
		FRZPT					FRZPT				
		1	2	3	4	Total	1	2	3	4	Total
SWAT	Mean	9.58	9.35	29.67	26.22	19.01	11.28	15.76	33.23	29.68	22.49
	Median	.00	.00	38.50	27.25	16.55	.00	16.55	35.55	43.83	16.55
	Mode	.00	.00	38.50	.00	.00	.00	.00	.00	49.15	.00
	Std Deviation	16.17	15.21	16.23	22.54	19.79	15.24	17.62	24.65	25.48	22.68
	Range	49.15	49.15	49.15	64.20	64.20	49.15	49.15	70.40	70.40	70.40
	Minimum	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	Maximum	49.15	49.15	49.15	64.20	64.20	49.15	49.15	70.40	70.40	70.40

TABLE 3. INDICES OF CENTRAL TENDENCY AND DISPERSION FOR SWAT – OSO

		MSN									
		1					2				
		FRZPT				Total	FRZPT				Total
		1	2	3	4		1	2	3	4	
SWAT	Mean	22.68	46.27	41.84	51.76	40.45	9.84	9.85	34.16	27.88	20.43
	Median	24.50	48.90	43.20	58.10	37.50	7.15	7.15	39.35	29.80	15.50
	Mode	.00	19.10	48.90	67.30	48.90	.00	.00	48.90	15.50	.00
	Std Deviation	21.48	27.66	7.65	30.60	24.89	12.38	12.14	22.86	16.99	19.28
	Range	48.90	80.90	15.40	100.00	100.00	34.60	33.50	67.00	48.90	67.00
	Minimum	.00	19.10	33.50	.00	.00	.00	.00	.00	.00	.00
	Maximum	48.90	100.00	48.90	100.00	100.00	34.60	33.50	67.00	48.90	67.00

TABLE 4. INDICES OF CENTRAL TENDENCY AND DISPERSION FOR SWAT – DSO

		MSN									
		1					2				
		FRZPT				Total	FRZPT				Total
		1	2	3	4		1	2	3	4	
SWAT	Mean	14.05	11.24	19.58	18.34	15.95	.00	6.11	22.51	17.74	11.59
	Median	.00	.00	14.90	.00	.00	.00	.00	16.70	7.15	.00
	Mode	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	Std Deviation	23.01	18.03	23.50	25.31	21.86	.00	8.54	22.95	21.90	18.08
	Range	63.50	48.90	63.50	48.90	63.50	.00	19.10	48.90	48.90	48.90
	Minimum	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	Maximum	63.50	48.90	63.50	48.90	63.50	.00	19.10	48.90	48.90	48.90

TABLE 5. CORRELATION COEFFICENTS - CREW

		CREW	MSN	FRZPT	SWAT
CREW	Pearson Correlation	1.000	.000	.000	.212*
	Sig. (2-tailed)	.	1.000	1.000	.001
	N	256	256	256	252
MSN	Pearson Correlation	.000	1.000	.000	-.109
	Sig. (2-tailed)	1.000	.	1.000	.084
	N	256	256	256	252
FRZPT	Pearson Correlation	.000	.000	1.000	.333*
	Sig. (2-tailed)	1.000	1.000	.	.000
	N	256	256	256	252
SWAT	Pearson Correlation	.212*	-.109	.333*	1.000
	Sig. (2-tailed)	.001	.084	.000	.
	N	252	252	252	252

* Correlation is significant at the 0.01 level (2-tailed)

TABLE 6. CORRELATION COEFFICIENTS - PILOTS

		CREWPOS	MSN	FRZPT	SWAT
CREWPOS	Pearson Correlation	1.000	.000	.000	-.060
	Sig. (2-tailed)	.	1.000	1.000	.504
	N	128	128	128	126
MSN	Pearson Correlation	.000	1.000	.000	.083
	Sig. (2-tailed)	1.000	.	1.000	.355
	N	128	128	128	126
FRZPT	Pearson Correlation	.000	.000	1.000	.372*
	Sig. (2-tailed)	1.000	1.000	.	.000
	N	128	128	128	126
SWAT	Pearson Correlation	-.060	.083	.372*	1.000
	Sig. (2-tailed)	.504	.355	.000	.
	N	126	126	126	126

* Correlation is significant at the 0.01 level (2-tailed)

TABLE 7. CORRELATION COEFFICIENTS - OSO

		CREWPOS	MSN	FRZPT	SWAT
CREWPOS	Pearson Correlation	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
	N	64	64	64	63
MSN	Pearson Correlation	.	1.000	.000	-.416*
	Sig. (2-tailed)	.	.	1.000	.001
	N	64	64	64	63
FRZPT	Pearson Correlation	.	.000	1.000	.383*
	Sig. (2-tailed)	.	1.000	.	.002
	N	64	64	64	63
SWAT	Pearson Correlation	.	-.416*	.383*	1.000
	Sig. (2-tailed)	.	.001	.002	.
	N	63	63	63	63

* Correlation is significant at the 0.01 level (2-tailed)

TABLE 8. CORRELATION COEFFICIENTS - DSO

		CREWPOS	MSN	FRZPT	SWAT
CREWPOS	Pearson Correlation	.	.	.	.
	Sig. (2-tailed)	.	.	.	.
	N	64	64	64	63
MSN	Pearson Correlation	.	1.000	.000	-.110
	Sig. (2-tailed)	.	.	1.000	.391
	N	64	64	64	63
FRZPT	Pearson Correlation	.	.000	1.000	.258*
	Sig. (2-tailed)	.	1.000	.	.042
	N	64	64	64	63
SWAT	Pearson Correlation	.	-.110	.258*	1.000
	Sig. (2-tailed)	.	.391	.042	.
	N	63	63	63	63

* Correlation is significant at the 0.05 level (2-tailed)

APPENDIX 9 – MANOVA TABLES FOR SWAT DATA

TABLE 1. REPEATED MEASURES MANOVA - MISSION AND FREEZE POINT
DEPENDENT MEASURE: SWAT
CREW

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
MSN	Pillai's Trace	.268	1.099	1.000	3.000	.371	.268
	Wilks' Lambda	.732	1.099	1.000	3.000	.371	.268
	Hotelling's Trace	.366	1.099	1.000	3.000	.371	.268
	Roy's Largest Root	.366	1.099	1.000	3.000	.371	.268
FRZPT	Pillai's Trace	.969	10.294	3.000	1.000	.224	.969
	Wilks' Lambda	.031	10.294	3.000	1.000	.224	.969
	Hotelling's Trace	30.883	10.294	3.000	1.000	.224	.969
	Roy's Largest Root	30.883	10.294	3.000	1.000	.224	.969
MSN * FRZPT	Pillai's Trace	1.000	2676.203	3.000	1.000	.014	1.000
	Wilks' Lambda	.000	2676.203	3.000	1.000	.014	1.000
	Hotelling's Trace	8028.610	2676.203	3.000	1.000	.014	1.000
	Roy's Largest Root	8028.610	2676.203	3.000	1.000	.014	1.000

TABLE 2. SIMPLE MAIN EFFECT MANOVA: FREEZE POINT
MISSION 1
CREW

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
FRZPT	Pillai's Trace	.795	5.177	3.000	4.000	.073
	Wilks' Lambda	.205	5.177	3.000	4.000	.073
	Hotelling's Trace	3.883	5.177	3.000	4.000	.073
	Roy's Largest Root	3.883	5.177	3.000	4.000	.073

TABLE 3. SIMPLE MAIN EFFECT MANOVA: FREEZE POINT
MISSION 2
CREW

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
FRZPT	Pillai's Trace	.748	4.958	3.000	5.000	.059
	Wilks' Lambda	.252	4.958	3.000	5.000	.059
	Hotelling's Trace	2.975	4.958	3.000	5.000	.059
	Roy's Largest Root	2.975	4.958	3.000	5.000	.059

TABLE 4. REPEATED MEASURES MANOVA – MISSION AND FREEZE POINT
DEPENDENT MEASURE: SWAT
PILOTS (FLIGHT CREW)

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
MSN	Pillai's Trace	.016	.048	1.000	3.000	.840
	Wilks' Lambda	.984	.048	1.000	3.000	.840
	Hotelling's Trace	.016	.048	1.000	3.000	.840
	Roy's Largest Root	.016	.048	1.000	3.000	.840
FRZPT	Pillai's Trace	.969	10.503	3.000	1.000	.222
	Wilks' Lambda	.031	10.503	3.000	1.000	.222
	Hotelling's Trace	31.508	10.503	3.000	1.000	.222
	Roy's Largest Root	31.508	10.503	3.000	1.000	.222

TABLE 5. REPEATED MEASURES MANOVA: MISSION AND FREEZE POINT
DEPENDENT MEASURE: SWAT
OSO

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
MSN	Pillai's Trace	.877	21.447	1.000	3.000	.019	.877
	Wilks' Lambda	.123	21.447	1.000	3.000	.019	.877
	Hotelling's Trace	7.149	21.447	1.000	3.000	.019	.877
	Roy's Largest Root	7.149	21.447	1.000	3.000	.019	.877
FRZPT	Pillai's Trace	1.000	4401.363	3.000	1.000	.011	1.000
	Wilks' Lambda	.000	4401.363	3.000	1.000	.011	1.000
	Hotelling's Trace	13204.090	4401.363	3.000	1.000	.011	1.000
	Roy's Largest Root	13204.090	4401.363	3.000	1.000	.011	1.000
MSN * FRZPT	Pillai's Trace	.920	3.830	3.000	1.000	.355	.920
	Wilks' Lambda	.080	3.830	3.000	1.000	.355	.920
	Hotelling's Trace	11.489	3.830	3.000	1.000	.355	.920
	Roy's Largest Root	11.489	3.830	3.000	1.000	.355	.920

TABLE 6. REPEATED MEASURES MANOVA – MISSION AND FREEZE POINT
DEPENDENT MEASURE: SWAT
DSO

Effect		Value	F	Hypothesis df	Error df	Sig.
MSN	Pillai's Trace	.074	.239	1.000	3.000	.658
	Wilks' Lambda	.926	.239	1.000	3.000	.658
	Hotelling's Trace	.080	.239	1.000	3.000	.658
	Roy's Largest Root	.080	.239	1.000	3.000	.658
FRZPT	Pillai's Trace	.892	2.758	3.000	1.000	.410
	Wilks' Lambda	.108	2.758	3.000	1.000	.410
	Hotelling's Trace	8.273	2.758	3.000	1.000	.410
	Roy's Largest Root	8.273	2.758	3.000	1.000	.410
MSN * FRZPT	Pillai's Trace	.990	33.226	3.000	1.000	.127
	Wilks' Lambda	.010	33.226	3.000	1.000	.127
	Hotelling's Trace	99.677	33.226	3.000	1.000	.127
	Roy's Largest Root	99.677	33.226	3.000	1.000	.127